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ABSTRACT

This handbook was developed to help the vocational teacher aid students in solving mathematical problems in vocational education classes. Most of the examples in the handbook were derived from metal-working and industrial mechanics classes; however, the procedures explained through them will work in any vocational class. The handbook is divided into seven major sections. The first six sections are organized on the basis of major strands in mathematics: measurement, fractions, decimals, percent, conversions, and geometry. Each of the six sections describes the concept, provides suggestions for a concrete-manipulative development of the concept, and provides a sampling of the variety of application-oriented activities. The last section contains ideas and references to enrich the teacher's efforts to improve mathematical skills of vocational students. In addition, information is provided for the teacher on the teaching-learning sequence in mathematics, attitudes toward mathematics, and suggestions for teaching the various concepts. (KC)

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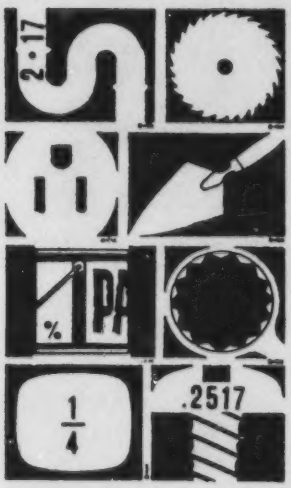
MATHEMATICS IN VOCATIONAL EDUCATION



Developed By

Lebanon Union High School

Vocational-Technical Education Department
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Division of Vocational Education
Oregon Department of Education

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PREFACE

This handbook was developed to help the vocational teacher help students do a better job of solving mathematical problems in order to be successful in vocational classes. Most of the examples in the handbook were derived from metalworking and industrial mechanics classes. However, the procedures explained here can and will work in any vocational class.

The Lebanon Union High School and the Vocational-Technical Education division at Oregon State University worked together to develop and test the ideas in this handbook. This effort was made possible through a grant from the Oregon Department of Education.

Our goal was not to make a mathematics teacher out of you, but to give you some very practical assistance in working with your students. The ideas in this handbook have worked for the teachers who have tried them. We sincerely hope that you will find these ideas useful.

ACKNOWLEDGMENTS

This document is the result of the generous and professional efforts of many persons. The contributions of numerous agencies which creatively helped develop the methodology are gratefully acknowledged. Without them, this handbook would not be a reality.

A special few guided and validated the work accomplished during this project.

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TABLE OF CONTENTS

	Page
Preface	i
Acknowledgements	ii
Orientation to the Handbook	1
Purpose	1
Handbook Organization	1
Using the Handbook	1
Teaching Learning Sequence	2
Attitudes Toward Math	3
Planning for Teaching	3
Planning Sheet	6
Assessment	7
Assessment Record	9
Measurement	11
Measurement Concepts	13
Skills	14
Pretest Ideas	14
Developing Judgment	15
The Steel Rule is the Simplest Tool	19
Blocks Teach Measuring Basics	21
Mini Metric Olympics	23
Fractions	25
Concept of Fractions	27
Skill Levels	27

Pretest ideas..... 28
Rule Divisions Enhance Concept of Fractions..... 29
Reinforcement of Fractions Operations..... 31
Applying the Skills in Written Form..... 33
Comparing Socket Sizes..... 34
Microcomputers..... 36
Decimals..... 41
Concept of Decimals..... 43
Skill Levels..... 43
Pretest Ideas..... 44
Teaching Fractional Concept of Decimals..... 45
Using the Feeler Gauge..... 47
Calculating Classified Ad Costs..... 49
Calculators and Decimals..... 51
Missing Parts..... 53
Percent..... 55
Concept of Percent..... 57
Skills..... 57
Pretest Ideas..... 58
Estimation With Percents..... 59
Use of Percent in Resistor Tolerance..... 71
Selling on Consignment..... 72
Conversions..... 73
Concept of Conversion..... 75
Skills..... 75
Pretest Ideas..... 76

Compression Ratio..... 77
Using Proportions for Conversions..... 78
Converting Drill Sizes..... 80
Top Speed, Overall Gear Ratio Calculator..... 82
Using a Graph in Automotive Applications..... 84
Geometry..... 87
Concept of Geometry..... 89
Skills..... 90
Pretest Ideas..... 90
Profile Puzzle..... 91
Cooperation Game..... 93
Using Models to Develop Intuition and Perspective..... 94
How Well Do You Stack Up This Time?..... 95
Developing Spatial Imagination..... 96
More Ideas..... 99
Problem Solving..... 101
Pool Patterns..... 102
Math Used in Jobs..... 103
When Are We Ever Gonna Have to Use This?..... 107
Use Calculators in Applied Problem Solving..... 111

ORIENTATION TO THE HANDBOOK

Purpose

-The purpose of this handbook is to help vocational teachers promote the development of student math skills in cluster programs.

Handbook Organization

-The handbook is divided into seven major sections.

-The first six sections are organized on the basis of major strands in mathematics: measurement, fractions, decimals, percent, conversions, and geometry.

-Each of the six sections describes the concept, provides suggestions for a concrete-manipulative development of the concept, and provides a sampling of the variety of application-oriented activities.

-The last section contains ideas/references to enrich your efforts to improve math skills of vocational students.

Using the Handbook

-First, review the table of contents and then skim the remainder of the book. (Ask your math specialist, teacher, and/or aide to review it with you).

-Read the following pages on the teaching-learning sequence and attitudes toward math.

-Make a copy of the planning sheet that appears at the end of this section and use it as you review the handbook.

-Now, locate the topic(s) you are interested in and read the concept background, teacher information, and suggested student activities. (Ask your math people to help you plan for teaching).

-Consult the enrichment activities for further ideas.

Teaching-Learning Sequence

In order for students to make good progress in vocational programs, teachers should introduce new topics in a concrete-manipulative mode, followed by a semiconcrete-pictorial mode, and finally, an abstract mode.

EXAMPLE

Reading a Resistor Color Code

1. Start with a Concrete-Manipulative Mode.

   - Provide students with an assortment of real resistors and a resistor color code chart.
   - Teach students how to interpret the chart and read colors from the body of a real resistor.
   - Have students read actual resistor values.

2. Now move to a Semiconcrete-Pictorial Mode.

   - Use color illustrations or photographs of resistors in groups on pages of a workbook, learning package, or other practice materials.
   - Using a color code chart, have students determine the value of the resistors shown on the practice materials.

3. Finally, use an Abstract Mode.

   - Introduce sentence problems to represent actions done with resistors (Concrete Mode) and pictures (Semiconcrete Mode).

Each time you plan a lesson, you need to decide which of the modes is the appropriate one to use. Unfortunately, the semiconcrete and abstract modes are often emphasized. However, the concrete mode should be used frequently, particularly as new topics and skills are introduced.

This handbook emphasizes the concrete-manipulative mode. A majority of the activities contained herein provides the concrete experiences students need to grasp the meaning of mathematics so they can make good progress in vocational programs. While handbook activities are content specific, they should be regarded as only examples of what can be done with students. The reader should be alert for application to his or her own teaching area. Handbook activities are generalizable to many vocational program areas.

Attitudes Toward Math

Teachers should recognize learning outcomes related to attitudes, interests, appreciations and anxieties. It has been assumed that mathematics is disliked by most young people. However, recent studies indicate that about as many students rate it as the subject they like best or second-best as those who indicate that it is the most disliked subject (Suydam and Weaver, 1975).

People who avoid math have difficulties with spatial visualization, logical reasoning and multi-step problem-solving. These are areas taught neither often nor well in the classroom. Some students learn these skills outside class, playing with blocks, tinkering with motors, playing computer games, experimenting with science kits. Girls have a special disadvantage in developing mathematical and traditionally male vocational skills because of stereotyped activities. Students become anxious when they need to use these skills and don't have them. This math anxiety leads students to avoid doing mathematics and pursuing traditionally male vocational interests.

Avoiding mathematics limits the student's vocational and career options. Vocational instructors should provide students with information regarding the importance of math in career choices. Outside speakers, especially women in non-traditional careers, are an important source of information. Teachers, too, can serve as effective role models by including math in their lessons.

Students who are anxious about math will benefit from more geometric and spatial exercises. Concrete models and practical applications should be part of math lessons. The opportunity to manipulate three dimensional models will strengthen concepts. Practical situations will provide relevance and meaning.

Perhaps the most effective remedial strategy is for students to do more math. Multi-step word problems, investigative problems and spatial visualization problems need to be incorporated into vocational courses. If a problem is solved by a cooperative effort and the process of reaching the solution is emphasized, a non-threatening environment is established. In this way, students begin to take risks, experience success, and develop a positive attitude toward mathematics.

Planning for Teaching

A summary of the National Council of Supervisors of Mathematics Position Paper on Basic Mathematical Skills may help you as you plan to incorporate the teaching of mathematics skills in your class:

> Mathematics supervisors are concerned that as a result of the "back-to-the-basics" movement, today in many schools there is too much emphasis on computation and not enough stress on other important mathematical skills. To respond to this trend, the National Council of Supervisors of Mathematics (NCSM) set up a twelve-member task force to write a position paper on basic mathematical skills. The position was first written in July, 1976, and later revised on the basis of ideas from supervisors throughout the country.

The position paper urges that we move forward, not "back" to the basics. The skills of yesterday are not the ones that today's students will need when they are adults. They will face a world of change in which they must be able to solve many different kinds of problems. The NCSM position paper lists ten important skill areas that students will need.

Problem Solving: Students should be able to solve problems in situations which are new to them.

Applying Mathematics to Everyday Situations: Students should be able to use mathematics to deal with situations they face daily in an everchanging world.

Alertness to Reasonableness of Results: Students should learn to check to see that their answers to problems are "in the ball park."

Estimation and Approximation: Students should learn to estimate quantity, length, distance, weight, etc.

Appropriate Computational Skills: Students should be able to use the four basic operations with whole numbers and decimals and they should be able to do computations with simple fractions and percents.

Geometry: Students should know basic properties of simple geometric figures.

Measurement: Students should be able to measure in both the metric and customary systems.

Tables, Charts and Graphs: Students should be able to read and make simple tables, charts, and graphs.

Using Mathematics to Predict: Students should know how mathematics is used to find the likelihood of future events.

Computer Literacy: Students should know about the many uses of computers in society and they should be aware of what computers can do and what they cannot do.

The role of computation is put into its proper place. Long computations will usually be done with a calculator, but computation is still important. Mental arithmetic is a valuable skill. Computational skills by themselves are of little use, but when used with other skill areas they give the learner basic mathematical ability. School systems which try to set the same requirements for all students should beware of requirements which either are too difficult or which stress only low-level skills.

Rather than using only a single method such as drill and practice for learning basic mathematical skills, many different methods should be used. Hands-on experience with physical objects can provide a basis for learning basic mathematical skills. Standardized tests are usually not suitable for measuring individual student progress. Instead, the tests used should be made espcially to measure the mathematical skills being taught.

The NCSM position paper sets forth a basis for identifying which basic mathematical skills are important and for determining if students have learned these skills.

An instructional planning sheet is shown on the following page. We suggest you use it as a guide to planning as you review the remainder of this handbook.

Planning Sheet
Using Student Activities

Procedures: Make a copy of this sheet and fill it out as you review the handbook.

- List those student activities you want to try.
- Identify the people who will help you, e.g. math specialist, teacher, aide.
- Specify where you want to try the activities, e.g. class and level.
- Indicate when you plan to try the activities, e.g. semester, date, time.
- Show how you plan to assess your efforts.

What activities do you want to try?	Who will help you?	Where will you try the activities?	When will you try them?	How will you assess your efforts?
Measurement				
Fractions				
Decimals				
Percent				
Conversions				
Geometry				

Make a copy of this page

Assessment

The process for assessing entering student mathematical skills levels should use methods that require applications of basic concepts. Avoid, whenever possible, reliance on only paper and pencil tests. Rather, systematically observe your students as they complete practical-manipulative activities you've assigned them.

This handbook contains examples of a variety of manipulative assignments. Each section also contains an assessment outline to help you organize an assessment for skills within the concept area. These outlines may help you build a paper and pencil assessment to complement your observations of the student in other manipulative activities. Systematically observe each student as they complete the activities, record their performance, analyze the records, and then prescribe remediation. Seek the assistance of the mathematics teachers in your school. Work with them to prescribe means to correct deficiencies and raise performance levels.

A performance record sheet has been developed to help you assess and continually monitor student progress. It follows on the next page. Duplicate the form and try it in your classes. You will want to use this assessment instrument in conjunction with the instructional planning sheet that also appears in this section.

You are not responsible for remediation of all the problems a student has with mathematics. Concentrate on those problems which inhibit success in the area you are teaching.

ASSESSMENT RECORD

Use this form to keep a record of student math skills development.

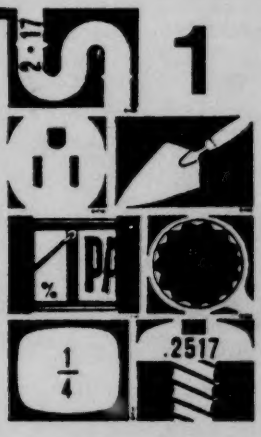
Procedures: Make a copy of this page
- Review the handbook and list those activities you will use to assess math skills.
- Get your math resource people to help you.
- Administer the activities, record student performance, and prescribe remediation.

List Student Names Below	List Assessment Activities Below							Describe Remediation Below
	Record Performance* and Date Below							

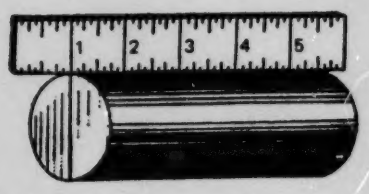
*Use the grading/performance criteria that you like best.

The appropriate computational skills must be learned with understanding for greatest applicability to real-life situations. Seldom do adults have to work a page of multiplication problems or work a problem where a formula is given. Our experiences with computations usually involve making a decision as to which computation must be made, doing the computation, and then making an evaluation of the answer to determine its reasonableness. To be able to make these decisions, computations, and evaluations, a person needs to have learned the appropriate computational skills through a variety of experiences that include concrete, representational, and abstract levels of instruction.

measurement



In order to determine why an answer is wrong, ask your students to explain how they got their answer. This will help you pinpoint that area which is causing difficulty.



Measurement Concepts

To measure is to make a comparison. An unknown magnitude is compared to a known magnitude. In order to measure, a unit of measure must be selected. The comparison results in a number called the measure. The measure and the unit of measure are called the measurement.

There are five measurement concepts that are developed over time:

1. A unit of measure is selected and applied to the object being measured.
2. All measurement is approximate rather than exact.
3. Units of measure that are applied directly must be of the same nature as the object being measured.
4. Units of measure must be uniform wherever they are used.
5. The basis for selecting a measuring instrument is the nature of the object to be measured.

Students need opportunities to use measuring instruments in a variety of settings once the instruments are introduced. This section provides the teacher with a variety of concrete-manipulative examples of how to help students measure using a variety of systems. The sample activities are not all inclusive; they are a sample of the activities which can be used in teaching the process and content in measurement.

Skills

The process of measuring is as important as the content associated with measuring. Skills associated with measurement include:

1. The concept of measurement using a standard reference.
2. The approximate nature of measures.
3. Estimation skills with a variety of scales.
4. Measurement in both the metric and English systems.

Pretest Ideas

A variety of measurement activities will give needed information on the students' skills in measurement.

Activities for the concept of measurement:

a. Using a paper clip as the unit of measure, have the students find the width of a desk. Estimate first and then find the length. Compare different students' estimates and measurements.

b. Have students independently use a meter stick to measure and record the length of a hallway to the nearest meter. Did all get the same measurement?

   Have students independently record the length to the nearest centimeter. Did all get the same measurement?

   Why are the measures different?

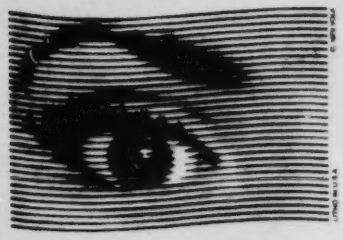
c. Have the students decide on an appropriate unit of measure, estimate, record the estimation, measure, and record the measurement of the following:

   (1) width of a staple
   (2) width of a ruler
   (3) distance from Portland, Oregon to Portland, Maine
   (4) a student's height
   (5) distance around a basketball
   (6) other items chosen by the students

d. Have students measure the time it takes to complete an activity. Estimate first.

e. Make a chart of comparisons of students' measurements of an objective when each student uses his/her own hand for a reference.

DEVELOPING JUDGMENT



THE (space) IN THE MIDDLE

ESTIMATING DISTANCE AND PROPORTION

Before your students become too dependent on the use of measuring tools, remember that judgement is a skill they will appreciate having.

Teach them first to estimate distance and proportion, rather than to rely on measuring tools. This skill will serve the students later when the tools are being used, to aid in a sense of whether answers are reasonable. Let them be accurate only where precise measurement is important.

SUGGESTIONS

Try using the following system to help your students gain confidence in their own judgment. You can even teach them to develop their own scales for drafting in odd proportions. You can have them compare divisions on an architect's scale, an engineer's scale, and the regular inch spacing of 16ths or 32nds.

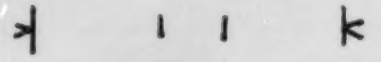
The point to understand about measurement is that each unit of measure in the begnning was an arbitrary choice.

Students who learn to make sound proportional judgments by estimation can more easily perceive when and where accuracy counts.

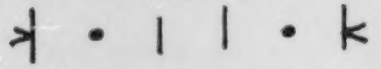
-Try the activities on the following pages-

Study this space:

Try to divide that space by visual judgement into five equal segments. It's easy if you think about the space in the middle:

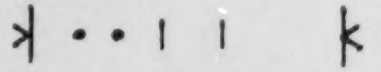


The middle space in five equal spaces has two equal spaces on each side. You look at the total space and imagine a space in the middle that will be the same as half of the space on either side:



This system of visual estimating has many advantages in working on sketches, on the chalkboard, in thinking in proportions instead of measurements, and in not having a rule at times. Now try this space: divide it into seven equal spaces.

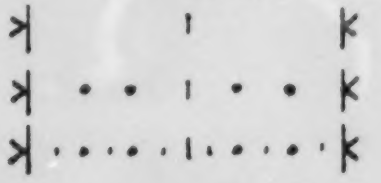
Are you thinking about the space in the middle? A middle space in seven is surrounded on each side by three spaces. First practice with thirds, then come back to this problem of seven spaces. Now try the seven. The space in the middle will be equal to 1/3rd of the space left on one side:



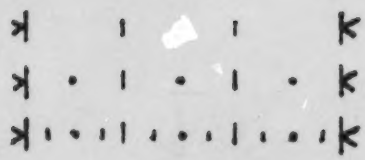
Now that wasn't so hard. This is a thought process as much as it is skill in judgment. You can start thinking in halves: that's easy. Then thirds: that becomes easy with practice. Then progress to fifths, sevenths, '3ths--even 17ths. (I use 17ths in a system of developing proportioned freehand perspective using measuring points.)

What about those divisions in between, you ask? Multiples of two--such as four, eight, sixteen--are easy to estimate. It's just a judgment of half and half again and again. Multiples of three follow the same scheme. Sixes are first thirds, then half of each space left. Nines are first thirds then thirds again. With twelve spaces you have a choice of approach:

<u>either</u>

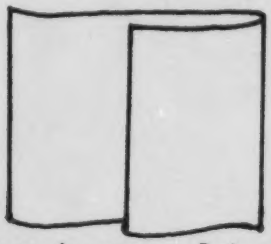


or

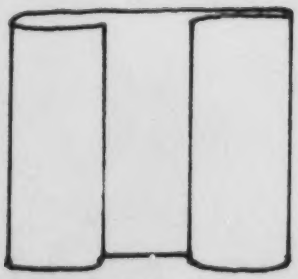


Try 13 spaces now. What is the space in the middle related to? The space in the middle of 13 spaces is surrounded by six equal spaces on each side. If you have practiced with developing sixes, you will find it easy to judge. Or, can you do a bit more difficult mental gymnastics? Imagine the space in the middle to be equal to one half of thirds. It's really not as difficult as it seems: try it!

You might like to begin teaching this process by dividing sheets of paper. To fold a piece of paper into thirds, simply think of the space in the middle. It will be equal to the fold on each side:



Of course, divisions into four is easy. But now try to fold paper into five equal spaces (sometimes you want to develop spaces into tens--we use tens in metrics, money, etc.):



The space in the middle is equal to half folds on each side. Try folding sevens.

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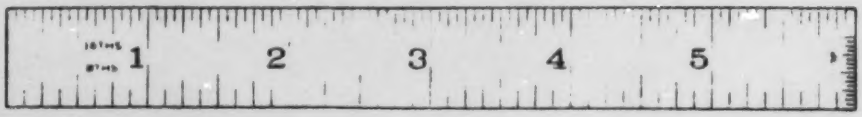
THE STEEL RULE IS THE SIMPLEST MEASURING TOOL IN THE SHOP.



READING THE RULE

A careful study of the enlarged section of the rule, Figure 1-1, will show the different fractional divisions of the inch from 1/8 to 1/64 in. The lines representing the divisions are called GRADUATIONS. On many rules, every fourth graduation is numbered on the 1/32 edge, and every eighth graduation on the 1/64 edge. You may wish to use this activity following the first activity in the FRACTIONS section.

As shown in Table 1-1, some steel rules are graduated in 10ths, 20ths, 50ths, and 100ths.

Fractional measurements are reduced to the lowest terms. A measurement of 14/16 is 7/8 and 2/8 is 1/4.

SUGGESTIONS

Some ways to help students learn to read the rule is to use the following activity sheets and:

1. Have them become thoroughly familiar with the 1/8 and 1/16 measurements.
2. Do the same with the 1/32 and 1/64 measurements.
3. Have them practice until they become proficient enough to read measurements accurately and quickly.

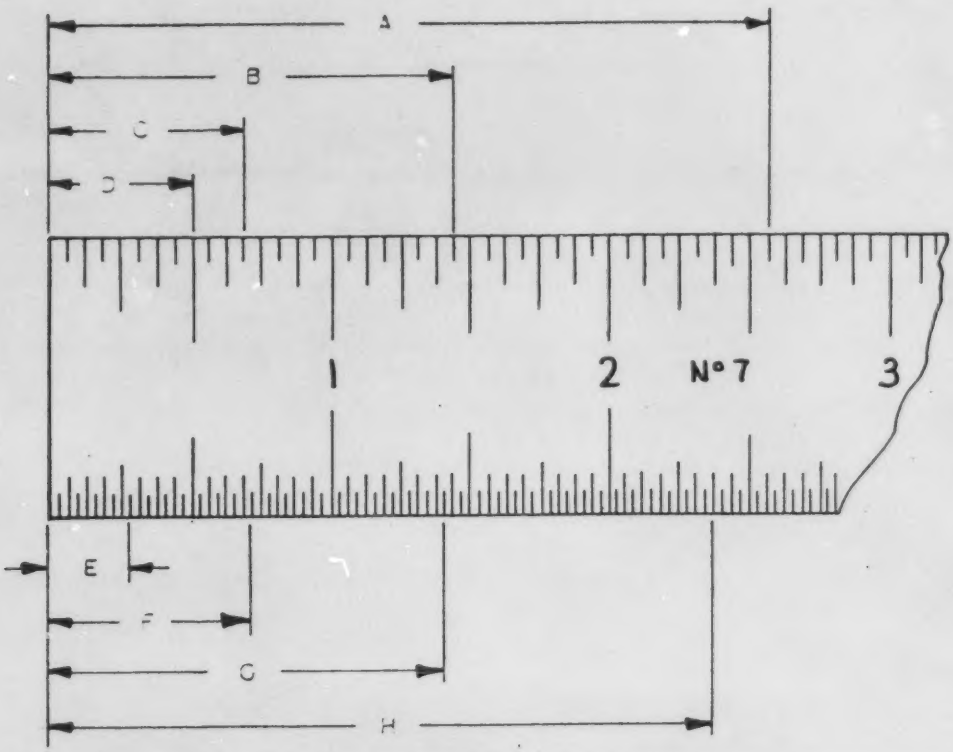
Provide students with additional practice as needed to read these rules accurately and quickly.

Have students practice reducing fractions to the lowest terms.

Table 1-1

Graduations	No. 1	No. 3	No. 4	No. 5	No. 6	No. 7	No. 9	No. 10	No. 11	No. 12	No. 18
First edge (Front Side)	10ths 20ths 50ths 100ths	32nds	64ths	10ths	50ths	100ths	--	64ths	64ths	100ths	100ths
Second Edge	12ths 24ths 48ths	64ths	32nds	100ths	50ths	64ths	64ths	32nds	100ths	50ths	50ths
Third Edge (Reverse Side)	16ths 32nds 64ths	50ths	16ths	64ths	10ths	16ths	32nds	---	---	---	32nds
Fourth Edge	14ths 28ths	10ths	8ths	32nds	10ths	32nds	16ths	---	---	---	64ths

Figure 1-1. A Section of a Steel Rule



How many measurements can you read? Place your answers below.

Measurement for A _____

Measurement for B _____

Measurement for C _____

Measurement for D _____

Measurement for E _____

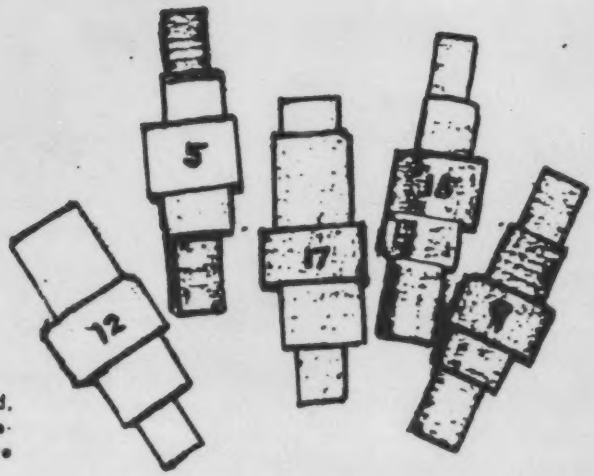
Measurement for F _____

Measurement for G _____

Measurement for H _____

Now ask your teacher to look at your answers.

BLOCKS TEACH MEASURING BASICS



Any number of different blocks can be designed, depending on the class size and amount of duplication desired. Five possible configurations are shown

TEACHING MEASURING BASICS

Vocational teachers are responsible for teaching the use of measuring tools, especially in beginning classes. Here is a good way to teach and test the English and/or metric system of measurement.

SUGGESTIONS

Form blocks of various sizes and shapes from pieces of scrap wood. In a class of 25 students, for example, five blocks of five different configurations could be made. Corresponding measurements on blocks of the same set must be identical.

Identify each block with a number, and label the top so that students will know where to begin their measurements. Numbering should be nonconsecutive within sets so that students cannot compare measurements. You should record the block numbers and all measurements of each set to establish a correction key.

Periodically check to make sure no one has written the measurements on the blocks, thereby defeating their purpose. Record the numbers of the blocks each student has measured so that blocks from different sets may be assigned for further practice and testing.

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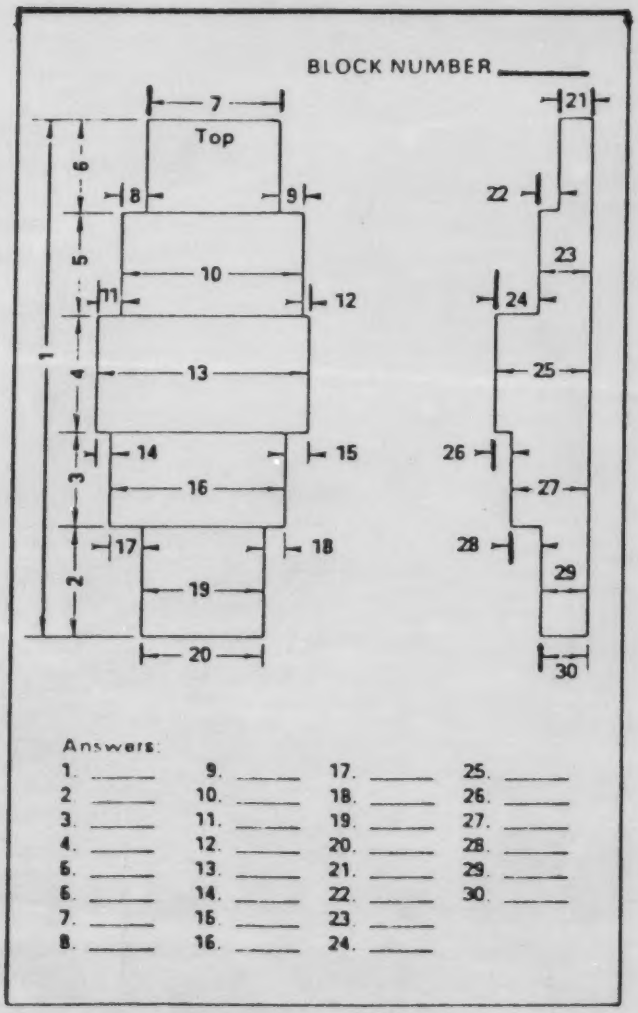
Measurement Exercise Sheet Follows

Measuring

Each person should have a numbered block, an answer sheet, a rule, and a pencil or pen. Be sure to put the number of the block in the space provided as the blocks are not all the same. Measure accurately; be sure you follow the numbers on the sketch even though your block may look different from the sketch. Carefully measure each area and write the dimension in the space provided.



Answers:

1. _____	9. _____	17. _____	25. _____
2. _____	10. _____	18. _____	26. _____
3. _____	11. _____	19. _____	27. _____
4. _____	12. _____	20. _____	28. _____
5. _____	13. _____	21. _____	29. _____
6. _____	14. _____	22. _____	30. _____
7. _____	15. _____	23. _____	
8. _____	16. _____	24. _____	

MINI METRIC OLYMPICS GIVES EXPERIENCES WITH THE METRIC SYSTEM

EVENT	ESTIMATE	ACTUAL	DIFFERENCE
1. Two-handed rule toss (in centimeters)			
2. Rubber stopper shot put (in meters)			
3. Discus paper plate throw (in decimeters)			
4. One-handed nail grab (weight of nails in grams)			
5. One-handed sponge squeeze (in cubic centimeters)			

USING THE METRIC SYSTEM

If you ask a student how tall s/he is, s/he can probably tell you in feet and inches. But, if you ask for the measurement in centimeters, s/he cannot even make a reasonable guess.

Students have not had experiences using the metric system. Activities which provide experiences in estimating and measuring in the metric units help the student become familiar with these units.

SUGGESTIONS

Give the students experiences in a game atmosphere by holding a Mini Metric Olympics. The purpose is for familiarity with the metric system including length, area, volume, weight. The method uses team competition. Try different events using equipment available in the classroom. Make the events fun.

Olympic Rules

1. Each member of the team competes in every event.
2. Each member gets only one try -- no practice.
3. Each member of the team trys each event, estimates the measurement (distance, weight, etc.), measures, and records the amounts.
4. The difference between the estimate and the actual measurement is computed (using absolute values, not signed numbers).
5. The team with the lowest total difference for all five events is the measurement gold medal team.

Description of Events

1. From starting line, holding the ruler with two hands, toss the ruler. Estimate the distance in centimeters. Measure to the nearest centimeter. Record.

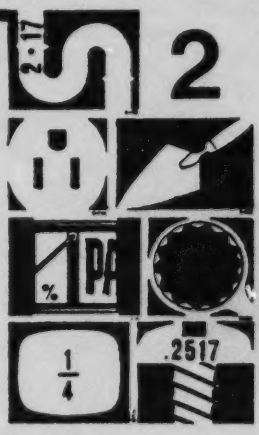
2. From the starting line, put the rubber stopper. Estimate in meters. Measure to the nearest meter. Record.

3. The discus is made of two paper plates taped together. From the starting line, toss the discus. Estimate the distance in decimeters. Estimate the distance to the nearest decimeters. Record.

4. Using a gloved hand, grab as many nails from a pan. Estimate the weight of the nails. Weigh the nails in grams. Record.

5. Hold saturated sponge over container. Squeeze with one hand to squeeze as much water as possible out of the sponge. Estimate the amount of water to the nearest cubic centimeter. Measure the water you squeezed to the nearest cubic centimeter. Record.

fractions



Remind students that fractions are just parts of a whole.

$$\frac{1}{4} \quad \frac{1}{2} \quad \frac{3}{4}$$

Concept of Fractions

Fractions are often useful for expressing parts of some unit, particularly in measurement activities. The concept of equal-sized parts is just one of the ideas students encounter in their study of fractions. Four main ideas must be shown in the activities used to develop the concept of fractions. They include:

1. The size and shape of the whole unit
2. The division of the whole into equal-sized parts
3. The number of equal-sized parts in the whole
4. The number of parts considered

Skill Levels

National assessment examinations in mathematics indicate secondary level students lack both computational skills and a conceptual understanding of fractions. Estimation skills with fractions cannot be successfully developed without a conceptual understanding of fractions and fractional operations.

Skill levels for fractions include:

1. Concept of fraction
2. Concept of fractional operations (addition, subtraction, multiplication, and division)
3. Estimation with fractional operations
4. Computation with fractional operations

Pretest Ideas

As part of your assessment of entering skills with fractions, you may wish to create a written assessment. However, be sure to use other means of determining entry level skills. When preparing a written form from this outline, it is important to create fraction exercises within a specific vocational pplication along with simple computation exercises. Be sure to use realistic fractions. You may need to read the problem to the student if reading skills are not adequate.

Skill 1: Concept of Fraction

Sheet metal is commonly found in sheets that are 3 feet by 8 feet. Five students must share a piece of sheet metal so that each student receives an equal amount. The dimensions of each of the five pieces are 3 feet by _____?_____ (expressed as a fraction).

Skill 2: Concept of Fractional Operations

Which operation (+, -, X, ÷) would you use to solve this problem:

An automobile jack raises the car 3/16 inch for each stroke of the lever. How many movements of the lever are required to lift the car 3 3/4 inches? *(p. 24, Mathematics for Automotive Trades)*

Skill 3: Estimation with Fractional Operations

Use of calculators encouraged. Use multiple choice of ranges for solutions.

Find a good estimate of the average speed in miles per hour of a car driven 203 miles in 3 3/4 hours.

a. 67-70 mph
b. 51-60 mph
c. 61-66 mph
d. 48-51 mph

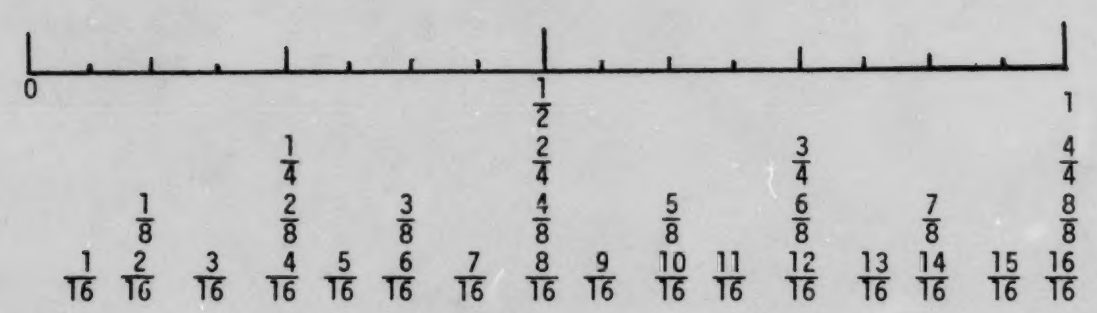
Skill 4: Computation with Fractional Operations

Use of calculators encouraged with both operation (A) and application (B) type problems.

A. 3/4 + 5/8 = _____

B. If the gasket holes are to be equally spaces, what is the center to center distance between the holes where the length F is 22½ inches?

RULE DIVISIONS ENHANCE CONCEPT OF FRACTIONS



BUILD A MEASUREMENT DEVICE

Development of a measurement device provides a concrete means of teaching fraction concepts. This activity also strengthens the concept of measurement. Refer to the steel rule activity in MEASUREMENT section.

SUGGESTIONS

Draw a horizontal line (about 2½ feet long) with intersecting lines at each end. Label the end points "0" and "1" to depict one unit.

Divide the horizontal line into halves with a vertical line at the middle (using a slightly shorter vertical). Indicate the distance from 0 to "½" mark and ask how much it is. Do the same with the last half of the unit. Write ½ under the "½" vertical divider and 2/2 under the unit 1-unit mark.

Divide the halves into halves again (using shorter vertical lines for the markings). Ask how many spaces now. Count and label all "¼" units.

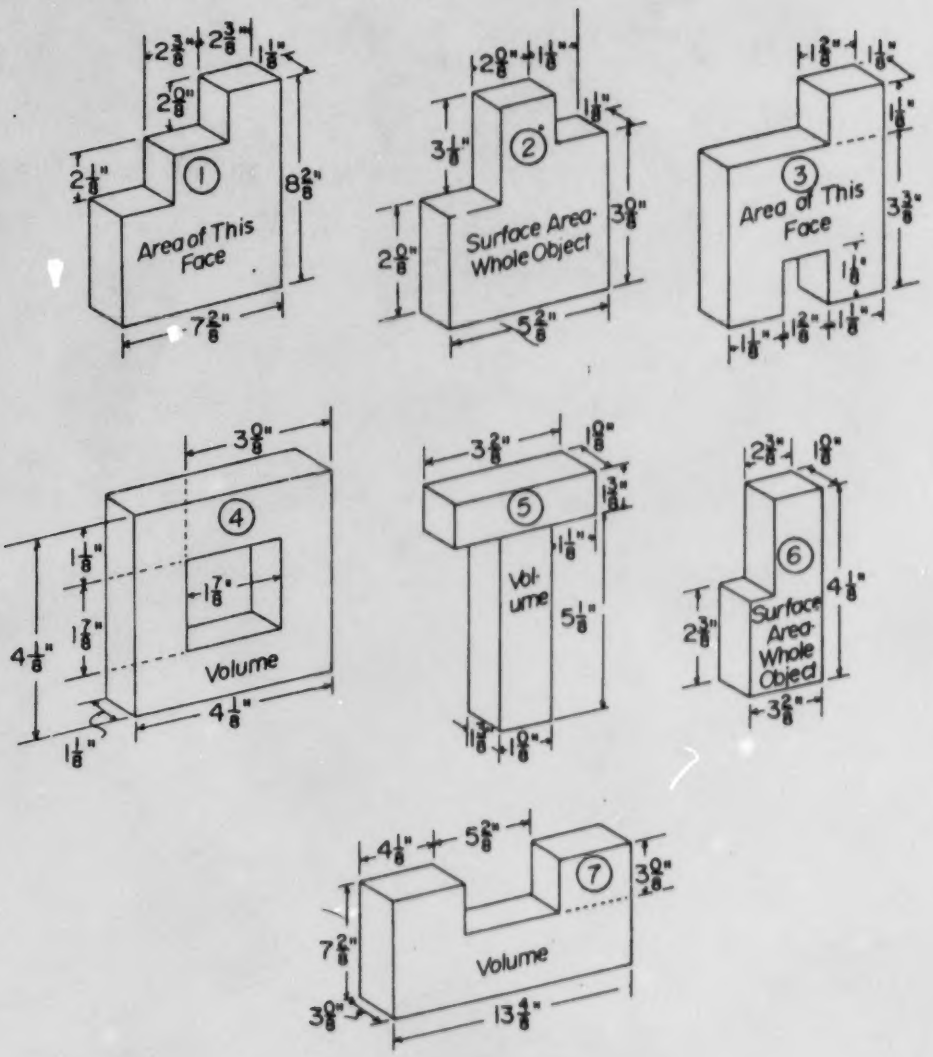
Repeat with eighths and sixteenths (see above).

Introduce concept of denominator as number of equal spaces in the unit. The number of equal spaces is represented by the numerator. Point out this fact; help students explain the fractions 1/4, 2/4, and 3/4 in this manner.

Introduce the concept of equivalent fractions. One-half is the same as 2/4, 4/8 and 8/16. Drill in this way: erase the fractional labels at the division lines and point out the matching sets of 4th lines, 8th lines, and 16th lines.

Adapted from the December, 1973 issue of School Shop with permission of the publisher.

REINFORCEMENT OF FRACTIONS OPERATIONS



Merealdi, R. W. "An application of Volume and Surface Area." Activities for Junior High School and Middle School Mathematics. National Council of Teachers of Mathematics, 1981, pg. 158.

REINFORCING OPERATIONS

Total surface area of a block is the sum of the areas of each face. This activity provides reinforcement in addition and multiplcation of fractions. The activity also gives work in perception and visualization of three-dimensional figures.

SUGGESTIONS

Have students determine the surface area of volume as indicated in the figures above. Use calculators to make calculations.

Additional activities

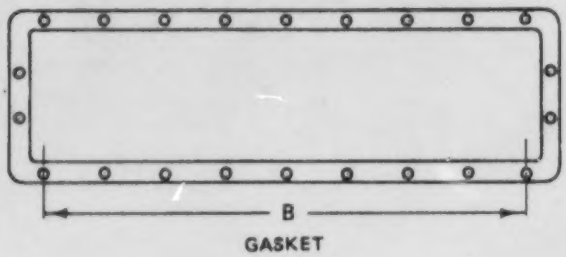
Have students make different wood shapes. Measure and calculate surface area and volume.

APPLYING THE SKILLS IN WRITTEN FORM

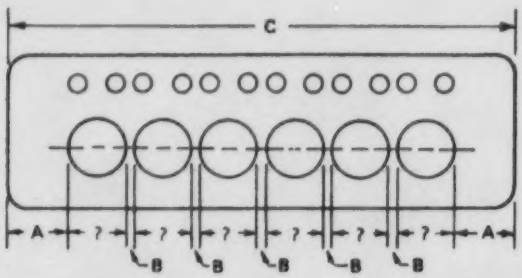
Many texts are available which provide written application problems for use as drill. Reading skills are needed for interpretation of the problems.

Here is a sample from *Practical Problems in Mathematics for Automotive Technicians by George Moore, Delmar Publishers, 1979, pg. 25-26.*

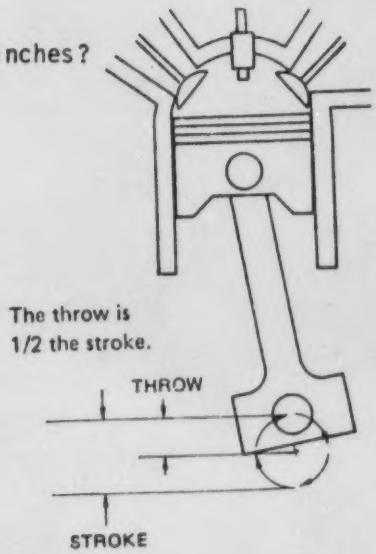
1. The gasket holes are equally spaced and B is 22 1/2 inches. What is the center-to-center distance between holes?



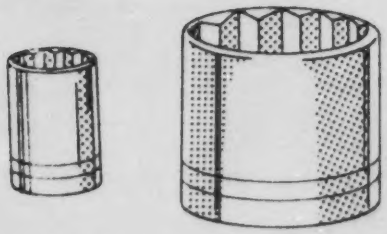
2. Distance A is 2 1/4 inches, distance B is 1 3/8 inches, and distance C is 36 1/8 inches. What is the diameter of each cylinder bore?



3. What is the crank throw when the stroke is 4 3/16 inches?



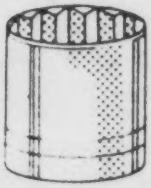
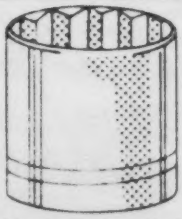
COMPARING SOCKET SIZES



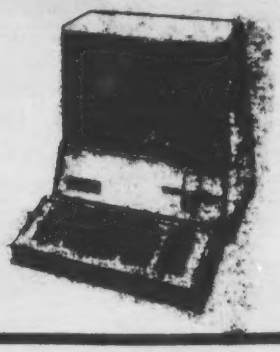
COMMENT

Here is an activity in estimation of decimal equivalents for fractions and the relationship of fractions with decimals. Sockets are sized in both metric and United States Customary System (USCS) sizes. Below are sets of sockets in each of these standards. Determine which socket is LARGER. Use a calculator to find the decimal equivalent in inches for the metric sizes. Estimate the decimal equivalent for the fraction and then calculate with the calculator (2.54 cm = 1 inch).

Socket	Metric Size	Decimal Equivalent in Inches			USCS Size
		Metric to inch Calculated	USCS Calculated	USCS Estimate	
	3 mm				$\frac{1}{8}$ INCH
	4 mm				$\frac{3}{16}$ INCH
	6 mm				$\frac{1}{4}$ INCH
	9 mm				$\frac{5}{16}$ INCH

Socket	Metric Size	Decimal Equivalent in Inches			USCS Size
		Metric to Inch Calculated	USCS Calculated	USCS Estimate	
	10 mm				$\frac{3}{8}$ INCH
	12 mm				$\frac{7}{16}$ INCH
	16 mm				$\frac{5}{8}$ INCH
	18 mm				$\frac{11}{16}$ INCH
	19 mm				$\frac{3}{4}$ INCH
	20 mm				$\frac{13}{16}$ INCH
	22 mm				$\frac{7}{8}$ INCH
	24 mm				$\frac{15}{16}$ INCH

MICROCOMPUTERS



Computers can make your job as teacher easier and less time consuming by assisting you with record keeping, analyzing and recording test responeses, developing IEP's, storing and presenting individualized instructional programs and performing math calculations. It is a power tool when used appropriately to supplement instruction and assist the teacher.

A sample microcomputer instructional program is included in this section. Please remember that this program is intended to supplement, not replace teacher directed instruction. These and other programs should be used to enhance instruction. This program is a sample drill which was originally written in Hewlett Packard Basic by Michael Garoutte, Linn-Mar Junior High School, Marion, Iowa. The program was adapted to Applesoft Basic. Below is a sample run and the listing.

```
                FRACTION DRILL
                ======== =====

THIS PROGRAM IS SET UP TO HELP YOU WORK
WITH FRACTIONS BY PROVIDING YOU WITH
EXPERIENCE NEEDED TO WORK WITH
FRACTIONAL MEASUREMENT.

YOU WILL NEED A PENCIL AND SCRATCH PAPEROR YOU MAY USE A CALCULATOR.
DO YOU HAVE BOTH OF THESE ITEMS?YES


WHAT IS YOUR FIRST NAME?  MAGGIE
IT IS A PLEASURE TO MEET YOU, MAGGIE.
YOU WILL BE WORKING WITH A 20 QUESTION
DRILL.  RELAX AND GOOD LUCK.


   #1
        4 / 4 = 2 / X
        WHAT IS THE VALUE OF X?2


NICE JOB, MAGGIE!


   #2
        2 / 16 = X / 8
        WHAT IS THE VALUE OF X?4

YOU HAVE SCORED 1 RIGHT, MAGGIE, SO FAR, BUT THIS ISN'T ONE.

THE CORRECT ANSWER IS 1
   #3
        2 / 8 =  X /16
        WHAT IS THE VALUE OF X?4


SEE, WHAT A BRAIN.


   #4
        8 / 8 =  X /16
        WHAT IS THE VALUE OF X?16


L U C K Y ! ! ! !
```

42

```
    #5
PUT THESE FRACTIONS IN ORDER STARTING
WITH THE SMALLEST AND GOING TO THE
LARGEST.  TYPE THE LETTER OF THE
SMALLEST BY THE NUMBER 1, THE LETTER
OF THE NEXT SMALLEST BY THE NUMBER 2,
AND SO ON.
          (A)  15/16
          (B)  4/8
          (C)  1/4
          (D)  3/8

WHAT IS THE CORRECT ORDER?
     1.?D
     2.?C
     3.?B
     4.?A

NOT BAD, NOT RIGHT BUT NOT BAD.

THE CORRECT ORDER IS- C,D,B,A.
    #6
        4 / 8 = 1 / X
        WHAT IS THE VALUE OF X??


GEE, WHAT A BRAIN.


    #7
        1 / 8 =  X /16
        WHAT IS THE VALUE OF X??


THE WIZZ KID STRIKES AGAIN.


    #8
        1 / 2 = 8 / X
        WHAT IS THE VALUE OF X?16


WOW, I'VE GOT A SMART ONE!!!!!


    #9
PUT THESE FRACTIONS IN ORDER STARTING
WITH THE SMALLEST AND GOING TO THE
LARGEST.  TYPE THE LETTER OF THE
SMALLEST BY THE NUMBER 1, THE LETTER
OF THE NEXT SMALLEST BY THE NUMBER 2,
AND SO ON.
          (A)  3/4
          (B)  3/16
          (C)  7/8
          (D)  1/2

WHAT IS THE CORRECT ORDER?
     1.?B
     2.?C
     3.?D
     4.?A

L U C K Y ! ! ! !


    #10
        1 / 4 = 4 / X
        WHAT IS THE VALUE OF X?16


IT'S A PLEASURE WORKING FOR SOMEONE
WHO GETS THEM RIGHT, MAGGIE


    #11
PUT THESE FRACTIONS IN ORDER STARTING
WITH THE SMALLEST AND GOING TO THE
LARGEST.  TYPE THE LETTER OF THE
SMALLEST BY THE NUMBER 1, THE LETTER
OF THE NEXT SMALLEST BY THE NUMBER 2,
AND SO ON.
          (A)  7/8
          (B)  3/4
          (C)  11/16
          (D)  4/8

WHAT IS THE CORRECT ORDER?
     1.?D
     2.?C
     3.?B
     4.?A


L U C K Y ! ! ! !


    #12
        12 / 16 = 6 / X
        WHAT IS THE VALUE OF X?8


GREAT MAGGIE UNBELIEVABLE, BUT GREAT!


    #13
        10 / 16 = X / 8
        WHAT IS THE VALUE OF X?2

YOU HAVE SCORED 10 RIGHT, MAGGIE, SO FAR, BUT THIS ISN'T ONE.

THE CORRECT ANSWER IS 5
    #14
        6 / 16 = X / 8
        WHAT IS THE VALUE OF X?3


WOW, I'VE GOT A SMART ONE!!!!!


    #15
        6 / 16 = 3 / X
        WHAT IS THE VALUE OF X?8


!!!!!!!!!!  FANTASTIC !!!!!!!!!


    #16
        12 / 16 = 6 / X
        WHAT IS THE VALUE OF X?8


NICE JOB, MAGGIE!


    #17
        1 / 2 =  X /4
        WHAT IS THE VALUE OF X??


L U C K Y ! ! ! !


    #18
        2 / 4 = 4 / X
        WHAT IS THE VALUE OF X?8


NICE JOB, MAGGIE!
```

```
#19
     8 / 8 = X / 2
     WHAT IS THE VALUE OF X?2

GEE, WHAT A BRAIN.

#20
     8 / 16 = X / 4
     WHAT IS THE VALUE OF X?2

IT'S A PLEASURE WORKING FOR SOMEONE
WHO GETS THEM RIGHT, MAGGIE


++++++++++++++++++++++++++++++++++++++++

  MAGGIE---YOUR SCORE IS:
     NUMBER          NUMBER
     WRONG           RIGHT       PERCENT
     3               17          85

++++++++++++++++++++++++++++++++++++++++

HAVE YOUR TEACHER TAKE A LOOK AT THIS
YOU MAY GET EXTRA CREDIT!
```

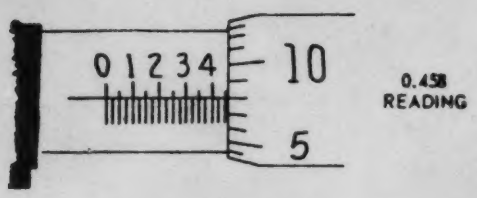
```
]LIST

1 S = PEEK (78) + PEEK (79) * 2
    56
2 X = RND ( - S)
10  TEXT : HOME
20  PRINT  TAB( 15);"FRACTION DRI
    LL"
30  PRINT  TAB( 15);"======== ===
    ==="
35  PRINT : PRINT
40  PRINT "THIS PROGRAM IS SET UP
     TO HELP YOU WORK"
41  PRINT "WITH FRACTIONS BY PROV
    IDING YOU WITH"
45  PRINT "EXPERIENCE NEEDED TO W
    ORK WITH"
46  PRINT "FRACTIONAL MEASUREMENT
    ."
50  PRINT
55  PRINT "YOU WILL NEED A PENCIL
     AND SCRATCH PAPER";
56  PRINT "OR YOU MAY USE A CALCU
    LATOR."
60  INPUT "DO YOU HAVE BOTH OF TH
    ESE ITEMS?";R$
70  PRINT : PRINT
80  IF  LEFT$ (R$,1) = "Y" THEN  GOTO
    145
85  PRINT "SINCE YOU DO NOT HAVE
    ALL OF THE "
86  PRINT "MATERIALS THAT YOU WIL
    L NEED,"
87  PRINT "PLEASE FOLLOW THESE IN
    STRUCTIONS:"
90  PRINT "  1.  GET THEM."
91  PRINT "  2.  RETURN TO TERMIN
    AL."
92  PRINT "  3.  TYPE 'READY' TO
    CONTINUE."
100 PRINT : PRINT
110 INPUT "I'LL WAIT ";S$
120 IF S$ = "READY" THEN  GOTO 1
    35
130 GOTO 92
135 PRINT
140 PRINT
145 HOME
146 INPUT "WHAT IS YOUR FIRST NA
    ME?  ";N$
155 PRINT "IT IS A PLEASURE TO M
    EET YOU, "N$;"."
160 PRINT "YOU WILL BE WORKING W
    ITH A 20 QUESTION"
161 PRINT "DRILL.  RELAX AND GOO
    D LUCK."
170 PRINT
175 PRINT
180 C = 0
185 FOR B = 1 TO 20
190 PRINT  TAB( 5)"#"B
200 A =  INT (3 * RND (1)) + 1
210 D = 2 ^ A
215 N =  INT ( RND (1) * D) + 1
220 P = 4 - A
225 G =  INT ( RND (1) * P) + 1
235 I = 2 ^ G
236 O = I * N
240 E = I * D
245 J =  INT ( RND (1) * 5) + 1
265 ON J GOTO 270,305,340,375,41
    0
270 PRINT  TAB( 10);N;" / ";D;"
    = ";" X /"E
271 PRINT  TAB( 10)"WHAT IS THE
    VALUE OF X"
280 INPUT H
285 IF H = O THEN  GOTO 1040
290 GOSUB 1255
295 PRINT "THE CORRECT ANSWER IS
     "O
300 GOTO 1170
305 PRINT  TAB( 10);N;" / ";D;"
    = ";O;" / X"
310 PRINT  TAB( 10);"WHAT IS THE
     VALUE OF X";
315 INPUT H
320 IF H = E THEN  GOTO 1040
325 GOSUB 1255
330 PRINT "THE CORRECT ANSWER IS
     ";E
335 GOTO 1170
340 PRINT  TAB( 10);O;" / ";E;"
    = X / "D
345 PRINT  TAB( 10);"WHAT IS THE
     VALUE OF X"
350 INPUT H
355 IF H = N THEN  GOTO 1040
360 GOSUB 1255
365 PRINT "THE CORRECT ANSWER IS
    "N
370 GOTO 1170
375 PRINT  TAB( 10);O;" / ";E;"
    = ";N;" / X"
380 PRINT  TAB( 10);"WHAT IS THE
     VALUE OF X";
385 INPUT H
390 IF H = D THEN  GOTO 1040
395 GOSUB 1255
400 PRINT "THE CORRECT ANSWER IS
    "D
405 GOTO 1170
410 PRINT "PUT THESE FRACTIONS I
    N ORDER STARTING"
411 PRINT "WITH THE SMALLEST AND
     GOING TO THE"
415 PRINT "LARGEST.  TYPE THE LE
    TTER OF THE"
420 PRINT "SMALLEST BY THE NUMBE
    R 1, THE LETTER"
421 PRINT "OF THE NEXT SMALLEST
    BY THE NUMBER 2,"
425 PRINT "AND SO ON."
430 G =  INT ( RND (1) * 10) + 1
440 ON G GOTO 445,505,560,620,68
    0,740,800,860,920,980
445 PRINT  TAB( 10);" (A)  1/2"
450 PRINT  TAB( 10);" (B)  3/4"
455 PRINT  TAB( 10);" (C)  1/4"
460 PRINT  TAB( 10);" (D)  3/16"

465 PRINT : PRINT  TAB( 5);"WHAT
     IS THE CORRECT ORDER?"
466 FOR I = 1 TO 4
467 HTAB (7): PRINT I".";
468 INPUT A$(I)
469 NEXT I
470 IF A$(1) = "C" AND A$(2) = "
    D" AND A$(3) = "A" AND A$(4)
    = "B" THEN  GOTO 1040
490 GOSUB 1255
495 PRINT "THE CORRECT ORDER IS:
    C,D,A,B."
500 GOTO 1170
504 PRINT  TAB( 10);" (A)  2/4"

505 PRINT  TAB( 10);" (A)  2/4"

507 PRINT  TAB( 10);" (B)  1/4"

510 PRINT  TAB( 10);" (C)  1/8"

515 PRINT  TAB( 10);" (D)  2/2"

520 PRINT : PRINT "WHAT IS THE C
    ORRECT ORDER?"
525 FOR I = 1 TO 4
530 HTAB (7): PRINT I".";
531 INPUT A$(I)
532 NEXT I
535 IF B$(1) = "C" AND B$(2) = "
    B" AND B$(3) = "A" AND B$(4)
    = "D" THEN  GOTO 1040
545 GOSUB 1255
550 PRINT "THE CORRECT ORDER IS:
    C,B,A,D."
555 GOTO 1170
560 PRINT  TAB( 10);" (A)  5/8"

565 PRINT  TAB( 10);" (B)  2/4"

570 PRINT  TAB( 10);" (C)  7/16
    "
575 PRINT  TAB( 10);" (D)  1/4"

580 PRINT : PRINT "WHAT IS THE C
    ORRECT ORDER?"
585 FOR I = 1 TO 4
590 HTAB (7): PRINT I".";
595 INPUT C$(I)
600 NEXT I
601 IF C$(1) = "D" AND C$(2) = "
    C" AND C$(3) = "B" AND C$(4)
    = "A" THEN  GOTO 1040
605 GOSUB 1255
610 PRINT "THE CORRECT ORDER IS:
    D,C,B,A."
615 GOTO 1170
620 PRINT  TAB( 10);" (A)  5/16
    "
625 PRINT  TAB( 10);" (B)  1/4"

630 PRINT  TAB( 10);" (C)  3/16
    "
635 PRINT  TAB( 10);" (D)  7/8"

640 PRINT : PRINT "WHAT IS THE C
    ORRECT ORDER?"
645 FOR I = 1 TO 4
650 HTAB (7): PRINT I".";
655 INPUT D$(I)
656 NEXT I
660 IF D$(1) = "C" AND D$(2) = "
    B" AND D$(3) = "A" AND D$(4)
    = "D" THEN  GOTO 1040
665 GOSUB 1255
670 PRINT "THE CORRECT ORDER IS:
    C,B,A,D."
675 GOTO 1170
680 PRINT  TAB( 10);" (A)  1/8"

685 PRINT  TAB( 10);" (B)  5/8"

690 PRINT  TAB( 10);" (C)  1/4"

695 PRINT  TAB( 10);" (D)  8/16
    "
700 PRINT : PRINT "WHAT IS THE C
    ORRECT ORDER?"
705 FOR I = 1 TO 4
710 HTAB (7): PRINT I".";
715 INPUT E$(I)
720 NEXT I
725 IF E$(1) = "A" AND E$(2) = "
    C" AND E$(3) = "D" AND E$(4)
    = "B" THEN  GOTO 1040
726 GOSUB 1255
730 PRINT "THE CORRECT ORDER IS:
    A,C,D,B."
735 GOTO 1170
740 PRINT  TAB( 10)"  (A)  15/16
    "
745 PRINT  TAB( 10)"  (B)  4/8"
750 PRINT  TAB( 10)"  (C)  1/4"
755 PRINT  TAB( 10)"  (D)  3/8"
760 PRINT : PRINT "WHAT IS THE C
    ORRECT ORDER?"
765 FOR I = 1 TO 4
770 HTAB (7): PRINT I".";
775 INPUT F$(I)
780 NEXT I
785 IF F$(1) = "C" AND F$(2) = "
    D" AND F$(3) = "B" AND F$(4)
    = "A" THEN  GOTO 1040
786 GOSUB 1255
790 PRINT "THE CORRECT ORDER IS-
    C,D,B,A."
795 GOTO 1170
800 PRINT  TAB( 10)"  (A)  7/8"
805 PRINT  TAB( 10)"  (B)  3/4"
810 PRINT  TAB( 10)"  (C)  11/16
    "
815 PRINT  TAB( 10)"  (D)  4/8"
820 PRINT : PRINT "WHAT IS THE C
    ORRECT ORDER?"
825 FOR I = 1 TO 4
830 HTAB (7): PRINT I".";
835 INPUT G$(I)
840 NEXT I
845 IF G$(1) = "D" AND G$(2) = "
    C" AND G$(3) = "B" AND G$(4)
    = "A" THEN  GOTO 1040
846 GOSUB 1255
850 PRINT "THE CORRECT ORDER IS
    D,C,B,A."
855 GOTO 1170
860 PRINT  TAB( 10);" (A)  3/4"

865 PRINT  TAB( 10);" (B)  3/16
    "
870 PRINT  TAB( 10);" (C)  3/8"

875 PRINT  TAB( 10);" (D)  1/2"

880 PRINT : PRINT "WHAT IS THE C
    ORRECT ORDER?"
885 FOR I = 1 TO 4
890 HTAB (7): PRINT I".";
895 INPUT H$(I)
900 NEXT I
```

```
901  IF M$(1) = "B" AND M$(2) = "
     C" AND M$(3) = "D" AND M$(4)
      = "A" THEN  GOTO 1040
905  GOSUB 1255
910  PRINT "THE CORRECT ORDER IS:
      B,C,D,A."
915  GOTO 1170
920  PRINT  TAB( 10);"  (A)  1/16
     "
925  PRINT  TAB( 10);"  (B)  1/8"

930  PRINT  TAB( 10);"  (C)  1/4"

935  PRINT  TAB( 10);"  (D)  1/2"

940  PRINT : PRINT "WHAT IS THE C
     ORRECT ORDER?"
945  FOR I = 1 TO 4
949  HTAB (7): PRINT I".";
950  INPUT I$(I)
955  NEXT I
960  IF I$(1) = "A" AND I$(2) = "
     B" AND I$(3) = "C" AND I$(4)
      = "D" THEN  GOTO 1040
965  GOSUB 1255
970  PRINT "THE CORRECT ORDER IS:
      A,B,C,D."
980  PRINT  TAB( 10);"  (A)  13/1
     6"
985  PRINT  TAB( 10);"  (B)  3/8"

990  PRINT  TAB( 10);"  (C)  5/16
     "
995  PRINT  TAB( 10);"  (D)  7/8"

1000  PRINT : PRINT "WHAT IS THE
     CORRECT ORDER?"
1005  FOR I = 1 TO 4
1010  HTAB (7): PRINT I".";
1015  INPUT J$(I)
1020  NEXT I
1022  IF J$(1) = "C" AND J$(2) =
     "B" AND J$(3) = "A" AND J$(4
     ) = "D" THEN  GOTO 1040
1025  GOSUB 1255
1030  PRINT "THE CORRECT ORDER IS
     : C,B,A,D."
1035  GOTO 1170
1040  REM  RANDOM REWARDS
1045 M =  INT ( RND (1) * 10) + 1

1046  PRINT : PRINT
1050  ON M GOTO 1065,1075,1085,10
     95,1105,1115,1125,1135,1145,
     1155
1065  PRINT "NICE JOB, "N$;"!"
1070  GOTO 1165
1075  PRINT "WHAT A STAR!;  WHAT
     A STAR!!"
1080  GOTO 1165
1085  PRINT "WOW, I'VE GOT A SMAR
     T ONE!!!!!"
1090  GOTO 1165
1095  PRINT "YOUR TEACHER MUST BE
      PRETTY SMART TO GET";
1096  PRINT "YOU TO SEE THAT ONE!
     "
1100  GOTO 1165
1105  PRINT "L U C K Y ! ! ! !"
1110  GOTO 1165
1115  PRINT "GREAT "N$;" UNBELIEV
     ABLE, BUT GREAT!"
1120  GOTO 1165
1125  PRINT "THE WIZZ KID STRIKES
      AGAIN."
1130  GOTO 1165
1135  PRINT "********** FANTAST
     IC *********"
1140  GOTO 1165
1145  PRINT "GEE, WHAT A BRAIN."
1150  GOTO 1165
1155  PRINT "IT'S A PLEASURE WORK
     ING FOR SOMEONE"
1156  PRINT "WHO GETS THEM RIGHT,
      "N$
1160  GOTO 1165
1165 C = C + 1
1166  PRINT : PRINT
1170  NEXT B
1175 W = 20 - C
1180 Y = C / 20
1185 I = ( INT (Y * 1000 + .5) /
     1000) * 100
1190  PRINT
1195  PRINT "++++++++++++++++++++
     ++++++++++++++++++"
1200  PRINT
1205  PRINT  TAB( 3);N$"---YOUR S
     CORE IS:"
1210  PRINT  TAB( 7)"NUMBER" TAB(
     20)"NUMBER
1215  PRINT  TAB( 7)"WRONG" TAB(
     20)"RIGHT" TAB( 30);"PERCENT
     "
1220  PRINT  TAB( 7);W; TAB( 20);
     C; TAB( 30);I
1225  PRINT
1230  PRINT "++++++++++++++++++++
     ++++++++++++++++++"
1235  PRINT
1240  PRINT "HAVE YOUR TEACHER TA
     KE A LOOK AT THIS"
1241  PRINT "YOU MAY GET EXTRA CR
     EDIT!"
1245  PRINT
1250  GOTO 1335
1255 Q =  INT ( RND (1) * 5) + 1
1260  PRINT
1265  ON Q GOTO 1280,1290,1300,13
     10,1320
1280  PRINT "I'M SORRY, ";N$;", Y
     OU MISSED THAT ONE."
1285  GOTO 1325
1290  PRINT "NOT BAD, NOT RIGHT B
     UT NOT BAD."
1295  GOTO 1325
1300  PRINT "YOUR TEACHER HAD BET
     TER WORK WITH"
1301  PRINT "YOU MORE."
1305  GOTO 1325
1310  PRINT "YOU HAVE SCORED "C"
     RIGHT, "N$", SO FAR, BUT THI
     S ISN'T ONE."
1315  GOTO 1325
1320  PRINT "THAT'S NOT RIGHT YOU
      TURKEY."
1325  PRINT : RETURN
1330  GOTO 1335
1335  END
```


46

decimals

Students should know that fractions based on the number 10 are called decimals. The placement of the decimal point is all that distinguishes these from whole numbers.



Concept of Decimals

A particularly useful notation for a fraction in real-life applications is the decimal. The decimal system is a system based on the division of a unit into ten equal parts, one-hundred equal parts, and so on. Both the fraction, 75/100, and the decimal, 0.75, illustrate 75 of 100 equal parts of a whole unit.

Decimals are used extensively in real-life situations. Availability of calculators have increased the use of decimal notations. It is particularly important to emphasize conversion of fractions to decimals along with use of calculator and estimation activities when teaching decimal concepts.

Skill Levels

1. Fractional concept of decimals
2. Conversions of fractions to decimals
3. Accuracy with decimals
4. Concept of decimal operations (addition, subtaction, multiplication, and division)
5. Estimation with decimal operations
6. Computation with decimals operations

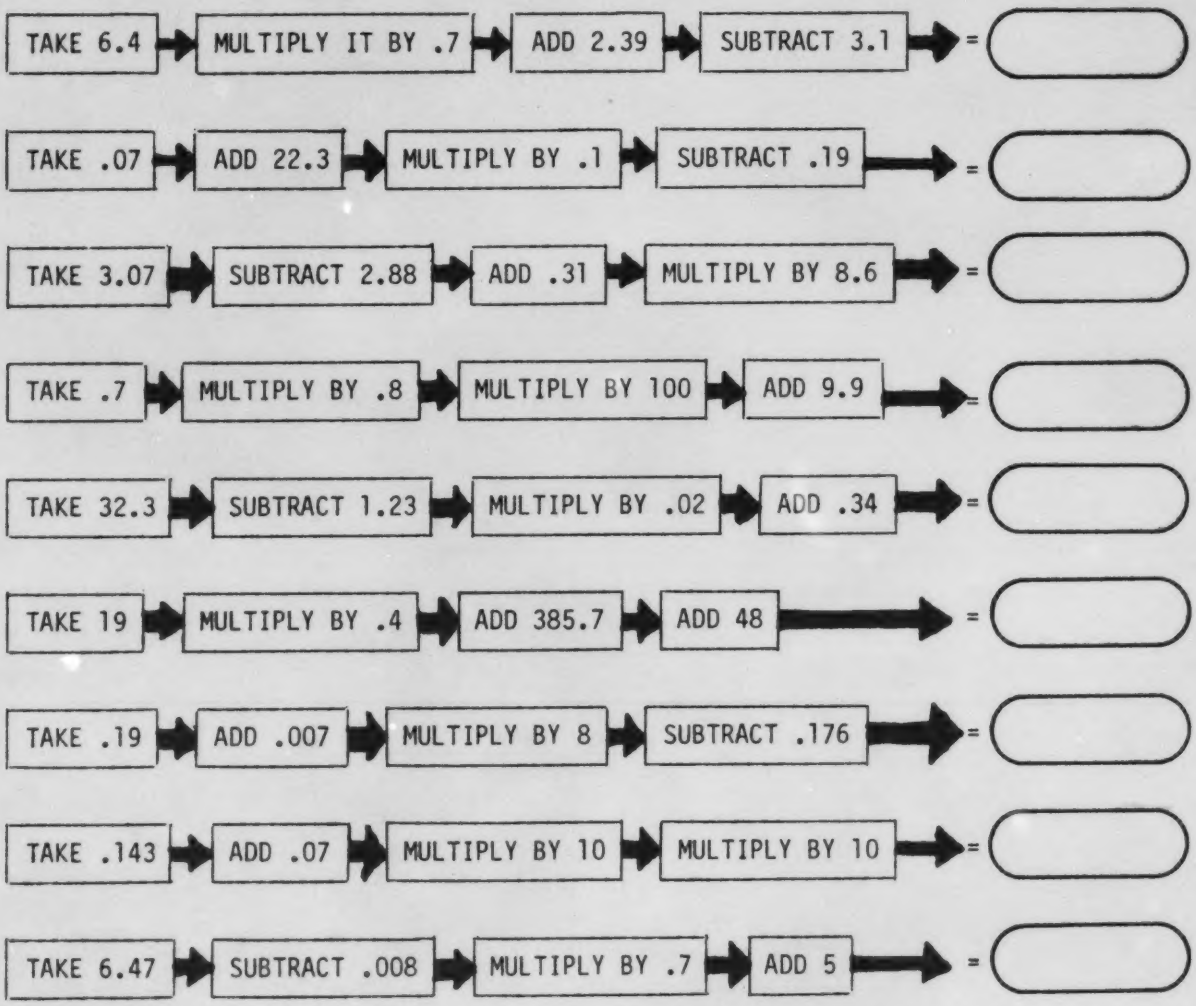
Pretest Ideas

The problems below can be used in variety of ways to determine different skill levels of students.

Directions:

Have students estimate which of the possible answers might be solutions to the problem. This activity gives you an indication of the student's concept of decimal operations.

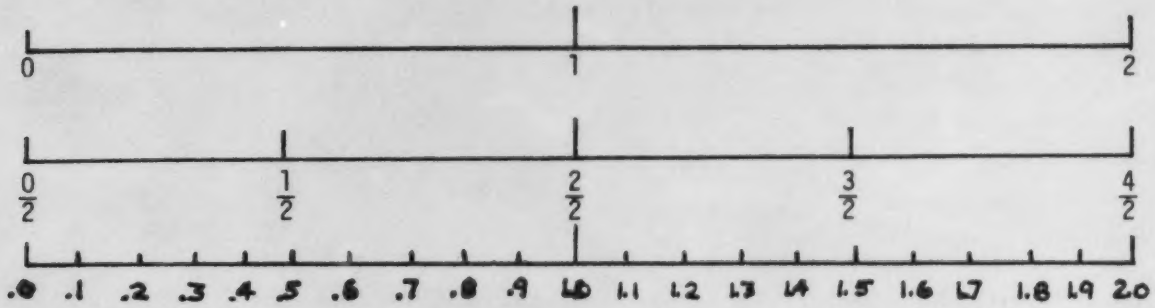
Second, have the students compute each of the following without the use of the calulator. Allow them check answers with the calculator. (Saves you time but also allows them to work with the calculator.)



POSSIBLE ANSWERS:

.8, .99, 65.9, 3.77, 4.3, 21.3, 1.4, 69.294, 4.3, 441.3, .9614, 2.047, 9.5234

TEACHING FRACTIONAL CONCEPT OF DECIMALS

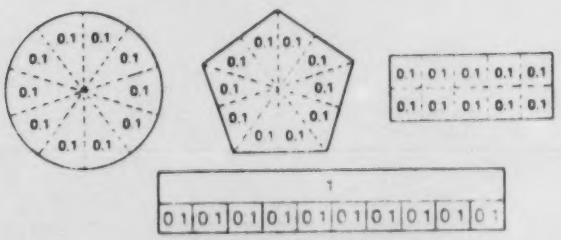


COMMENT

The teaching-learning sequence should move from the concrete-manipulative through the semiconcrete-pictorial to the abstract. A good developmental activity of the concept of decimals as fractions at the semiconcrete-pictorial level may be appropriate for most high school students. Extension of the rule divisions activity with fractions to rule divisions with decimals is recommended to enhance the relationship of decimals to fractions.

ACTIVITY

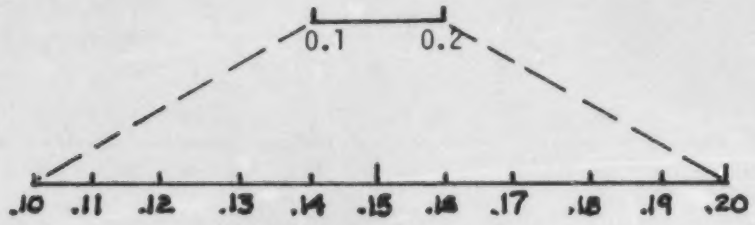
- Make a unit strip separated into ten equal parts. Other geometric shapes than linear representations can also be separated into ten equal parts.



- Number lines. You can use ruled-number lines to develop understanding of decimal fractions. Begin with a line that shows only unit segments. On a second line show each unit marked into ten congruent segments.

  The students should identify and name each point on the line as its meaning is discussed. Separation of each of the ten congruent segments helps develop an understanding of hundredths. Even though it may be

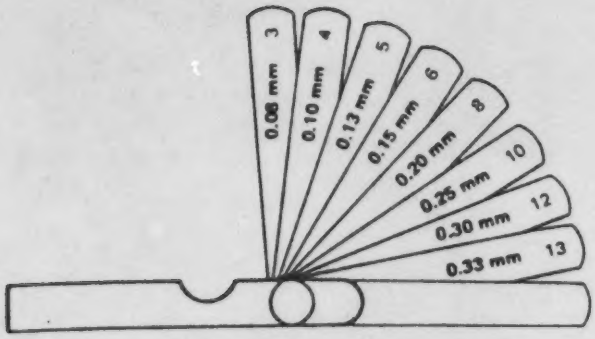
impractical to write the numeral for each hundredth-point on the line, students can recite the decimal name as parts of hundredths. A magnified version of one of the tenths parts may be used to show the sequence for decimal notion with hundredths.



The fact that ten-hundredths, 0.10, is equivalent to one-tenth, 0.1, should be emphasized as these materials are used.

Learning aids for representing fractional numbers smaller than hundredths are difficult to make in sizes that are practical for students to manipulate. A roll of adding machine tape can be useful for developing a large enough scale for use during discussion of decimal fractions smaller than hundredths.

USING THE FEELER GAUGE



COMMENT

Vocational students must have a working knowledge of decimal fractions. A good concrete-manipulative exercise that will help build these skills is to check piston ring clearance with a feeler gauge. Needed experiences with decimals can be extended through pictorial representations of the feeler gauge. Pictoral extensions help the student internalize work with the gauge as well as with decimal operations. Pages of problems are abstract activities which should be used sparingly.

ACTIVITY

Provide students with a feeler gauge and piston complete with rings. Have students check the clearance between the side of the piston ring and the ring groove in the piston. Determine the clearance by inserting feeler gauges of various thicknesses until one is found that fits snugly. Have each student read the number on that gauge and check it against specifications.

Discussion of this activity should center on the meaning of the "numeral" designation which the students found from the gauge. For example, .15 mm indicates the clearance is 15 hundredths of a millimeter; if a millimeter were divided into one hundred equal parts, 15 of the parts would represent the clearance. Discussion might also include a comparison of use of decimals with fractions to show the usefulness of decimals for accuracy.

Try some of the semiconcrete-pictorial activities to develop estimation and operation concepts with decimals. Extend these activities with your own exercises.

CARS FOR SALE

Calculating Classified Ad Costs

COMMENTS

Use your students' interest in buying and seeling cars to help them with their basic math skills. Give them the classified advertising rates of your local newspaper. Then give them the following two activities and require that they calculate the costs of each advertisement.

STEPS

1. Give students the classified ads rates, e.g.

   Example: 15¢ per word, minimum $3.00 per ad. Count name and address as words, phone number with area code counts as one word; no charge for zip code. Photo charge is $3.00.

2. Now give your students some classified sections. Ask them to select one ad, and using the rates given calculate the cost of that ad.

3. Finally, require each student to write their own classified ad for something.

Student Activity Sheet Follows

Calculating Classified Ad Costs

1. Figure out the cost of the following ad using these classified ad rates.

15¢ per word, minimum $3.00 per ad. Count name and address as words, phone number with area code counts as one word; no charge for zip code. Photo charge is $3.00.

1971 BOSS 351 MUSTANG. Mint condition, 60,000 miles. All factory original, yellow with black trim, Hurst 4-speed, posi-traction, PS, PB, headers, ram-air. Deluxe interior. Curt Martin, 20785 Napa Ave., Middletown, CA 95461 (707) 987-3380 weekends, or (916) 788-1149 weekdays. Price $4,950.

The cost of this ad is $_____

2. Now write your own classified ad for something you wish to sell.

_____

_____

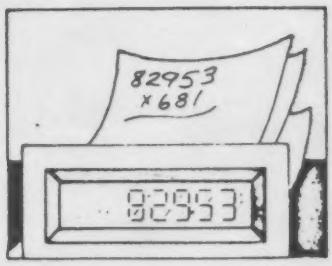
_____

_____

The cost of this ad is $_____

-Now check with your teacher-

CALCULATORS AND DECIMALS



COMMENT

Calculators are rapidly becoming a part of the learning aids in vocational laboratories. Decreasing cost makes them more accessible to all students. Accessibility to calculators permits a more powerful problem solving approach by freeing the student from tedious, repetitious computation. Teaching mathematical concepts, estimation, and problem solving can be enhanced with the use of the calculator. The calculator can handle messy, large numbers that are more realistic for vocational situations. Such problems can even be done by students who have not yet mastered the computational algorithm since the calculators allow the student to focus on which operation to use in a given situation rather than how to do the computation.

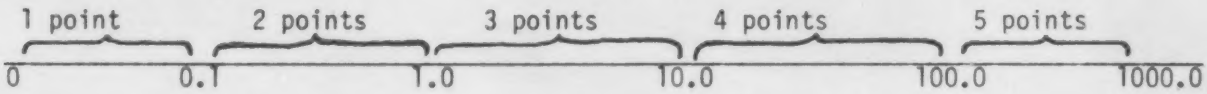
Estimation and recognition of reasonable results are skills particularly important in many vocational applications. Skill in making estimations and recognition of reasonableness are also important with calculator work. Here are some activities which use the calculator but also require estimation practice with decimal operations.

ACTIVITIES

- Use estimation to locate the decimal point in each of the following: Then use your calculator to check to see if you were correct.

6.7 + 5.2 + 9.6	=	215
47.58 - 8.71	=	3887
23 x 4.2	=	966
74.23 x .061	=	452803
56.925 ÷ 0.9	=	6325

- Provide students with a list of about 20 decimal numbers ranging from about 0.01 to 30.0. The student circles any two numbers and uses a calculator to determine the product. Depending on the size of the product, the student receives points according to the following scale.



The goal is to score 15 points by making six or fewer products.

- This activity combines problem solving skills with estimation. Use of the calculator aids in problem solving skills of guess, check, and refine. In all cases students must apply what is known about basic facts of decimals in order to complete the activity.

From 67 Ten-Minute Calculation Activies by Charles Thompson, Calculator Information Center, Information Bulletin No. 10, February 1981.

MISSING PARTS

The numbers in each column are to be used to complete the problems involving that operation. For example, the numbers in the addition column are to be used to complete the addition problems. An extra number is contained in each column.

Addition	Subtraction	Multiplication	Division
84.59	9.9	3.7	6
73.9	8.93	6	15.6
15.7	5.93	8.08	.8
18.77	17.2	5.88	3
79.2	4.6	9.31	14.6
89.9	12.12	1.9	9.66
97.6	20	2.14	3.2

1. ◯ + ◯ = 105.6	2. ◯ - ◯ = 8.27	3. ◯ x ◯ = 7.918
4. ◯ ÷ ◯ = 5.2	5. ◯ + 23.7 = ◯	6. ◯ ÷ 1.61 = ◯
7. ◯ - 14.07 = ◯	8. ◯ x .98 = ◯	9. 14.5 - ◯ = ◯
10. 2.56 ÷ ◯ = ◯	11. 5.39 + ◯ = ◯	12. 4.9 x ◯ = ◯

MISSING PARTS

Mathematics teaching objectives:

- Estimate.
- Uses a calculator.
- Use inverse operations.

Problem-solving skills pupils might use:

- Makes reasonable estimates as answers.
- Guess, check, and refine.
- Apply what you know about basic facts.
- Work backwards.

Materials needed:

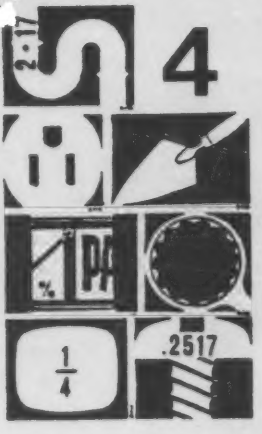
- Calculator

Comments and suggestions:

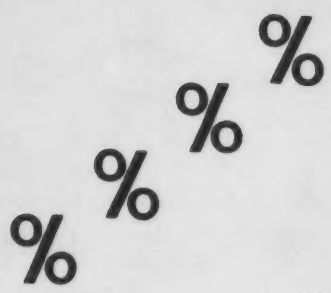
- Two distinct problem-solving strategies are possible. Some pupils will use a guess and check approach. Others will analyze the data, recognize limits; and apply what they know about basic facts.
- Remind pupils that each column contains an extra number. They can cross of each number as it is used.
- Pupils might enjoy making up their own problems to share with others.

Lane County Math Project, Eugene, Oregon.

percent



By learning the meaning of percent as a ratio and learning to solve a proportion, a student can solve any percent problem.



Concept of Percent

A great number of students have a poor conception of percent. They may do well with fractions and decimals and, yet, when presented with similar problems with percents, they become totally confused. Probably the major reason for this disability is related to formula-oriented teaching. The student who understands that percent is a means of making a comparison with 100 and that percent is a ratio can solve any percent problem by setting up a proportion and solving for the unknown.

There are a great many applications of percent in real-life situations. The computational skills with percent must be learned with understanding for the greatest applicability to real-life situations. By learning the meaning of percent as a ratio and learning to solve a proportion, the student can more easily learn to apply percent in real-life problems.

Skills

1. Concept of percent as means of comparing a number with 100.
2. Estimation with percents.
3. Application and computation with percents.
4. Application of percents.
5. Computation with percents.

Pretest Ideas

One method of determining what students understand about percents is to have them work with some incomplete problems. The types of additional information they request can give you an indication of their understanding of percents. Having them make up realistic information to complete the problem and having them estimate the answer gives you some indication of their facility with percent problems. This activity can be repeated after instruction to give some indication of the learning.

Directions:

Carefully read each problem. Supply information so that each problem is complete. Then estimate the answer.

1. Steve had to pay a 15% down payment on a bicycle. About how much was his down payment?

2. Susan had a score of 80%. How many problems were on the test?

3. Al has $791.37 in his savings account. About how much interest will he receive this year?

4. Janet had to pay a 6% sales tax on a radio. About how much tax did she pay?

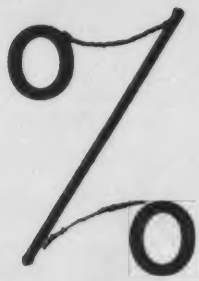
5. 205 students were at the game. About what percent of the student body was this?

6. Tony bought a motorcycle for 75% of its regular price. About how much did he have to pay for the motorcycle?

7. Calvin has read about 50% of a novel. About how many pages does the novel have?

8. Coach Shoff will get a 20% discount by buying a certain number of cans of tennis balls. About how much money will he save?

ESTIMATION WITH PERCENTS



COMMENT

Helping students make estimations when percents are involved provides students with an intuitive feeling for dealing with percents. Without this preceeding work, students tend to approach problems dealing with percents in a rote, formula orientation rather than with understanding for the concept of percent. As a result, they tend to be easily confused with percent problems!

Focus on estimation with percents in the beginning. After all, in real-life applications estimates are very often good enough to help make decisions as to whether to proceed.

The following activities are subsets of the types of activities which you should use with your students when beginning to work with percents.

ACTIVITIES

Good percent estimators do not confine themselves to one set method for coming up with their approximations. They use different methods, depending upon the context of the problem and their personal preferences. Therefore, good practice for "would-be" estimators is to have them look at percent from different points of view. In the first three activities three different estimation methods are presented. In the last activity encourage students to use whatever method seems natural to them. The three different estimation methods are indicated in the following examples.

Lane County Math Project, Eugene, Oregon.

Example 1: Bob made an 8% commission on a Buick he sold for $1295. Estimate his commission.

- Meaning of Percent Method (or "for every hundred" method)

  1295 is about 1300

  8% means 8 for every hundred

  Since there are 13 hundreds, the comission is 13 x 8 or $104

- One-Percent Method

  100% is approximately 1300

  1% is 13

  8% is 8 x 13 or $104

- Fraction Method

  8% is $\frac{8}{100}$ or approximately $\frac{1}{12}$

  $\frac{1}{12}$ of 1300 is about $108

Example 2: Miss Collins sold her car for $1495. This is about 75% of what she paid for it. About how much did she pay for the car?

- Meaning of Percent Method

  $1495 is close to $1500

  75% means $75 for every $100

  There are 20 $75's in $1500

  The original price of the car is 20 times $100 or $2000

- One-Percent Method

  $1495 is about $1500

  75% is about $1500

  1% is $20

  100% is $2000

- Fraction Method

  $1495 is close to $1500

  75% is $\frac{3}{4}$

  $\frac{3}{4}$ of the amount is $1500

  $\frac{1}{4}$ of the amount is $500

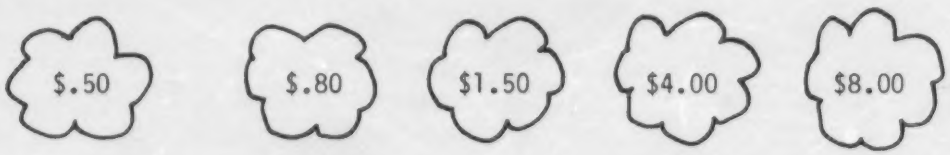
  $\frac{4}{4}$ of the amount is $2000

METHOD ONE -- MEANING OF PERCENT

Estimation is one of the most practical applications of mathematics. In this unit, you will learn several estimation methods useful in situations dealing with percent.

Remember -- don't be afraid to make estimates. The estimate you make is not wrong. It may not be as close as you'd like, but you'll get better with more practice.

Miss Green often eats out on Sunday afternoon. Last Sunday her bill was $7.95. Miss Green usually leaves a tip of about 10%. Which amount below do you think is closest to 10% of the bill?



Why is an $8.00 tip unreasonable?

Why is a $4.00 tip unreasonable?

If you thought an $.80 tip is most appropriate, you were correct. Perhaps you arrived at your estimate in the following way:

$7.95 is close to $8.00
10% means 10¢ for every dollar
or $.80 for every $8.00

This estimation method is called the MEANING OF PERCENT METHOD.

MEANING OF PERCENT

Mathematics teaching objectives:

- Use rounding and mental arithmetic in making estimates.
- Estimate answers to percent problems in a variety of settings.
- Use the "meaning of percent" method for making estimates.

Problem-solving skills pupils might use:

- Record appropriate values in a table.
- Create other problems which can be solved by certain procedures.
- Solve an easier but related problem.

Materials needed:

- None

Comments and suggestions:

- Help pupils overcome some of their reluctance to make estimates by reminding them that often problems can be made easier if the numbers are rounded. One way to teach pupils to round and estimate is by making it obvious to them that you get reasonable answers that way.
- This lesson should help accomplish this objective.
- The "meaning of percent" method is a natural way to think of percent. "Per" in percent is then used in the same way as the "per" in per hour or in per gallon.
- After working the Class Exercises, pupils should be able to do the remaining exercises individually. After pupils have done what they can on their own, they might profit from comparing their answers with one or more of their classmates.
- All of the word problems are examples of the type "Find a given percent of a given number."

MEANING OF PERCENT (Cont'd.)

Class Exercises

1. Remember, Miss Green usually leaves a tip of about 10%. Complete the chart below.

Cost of Meal	Approximate Tip
$ 5.95	?
$12.25	?
$ 3.10	?
$14.50	?

2. Mr. Miser usually leaves a tip of about 5%. Complete this chart.

Cost of Meal	Approximate Tip
$ 4.15	?
$ 6.75	?
$ 7.85	?
$11.25	?

Exercise

1. A 12% downpayment is required on all items. Remember 12% means 12¢ on every dollar, or $12 on every $100.

   Complete this chart.

Item	Cost	Approximate Downpayment
T.V.	$ 195	
Stereo	$ 415	
Davenport	$ 799	
Water Bed	$ 550	

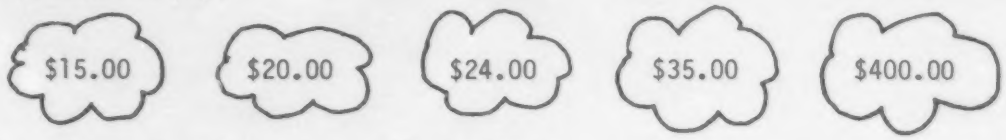
CLASS EXERCISE ANSWERS

1. $ .55 to $ .65 ($ .60); $1.20 to $1.30 ($1.23)
   $ .30 to $ .35 ($ .31); $1.40 to $1.50 ($1.45)
2. $ .20 to $ .25 ($ .21); $ .30 to $ .35 ($ .34)
   $ .35 to $ .40 ($ .39); $ .55 to $ .60 ($ .56)

METHOD TWO -- ONE PERCENT METHOD

Miss Haines needs to borrow $790 and the Easy-Cash Loan Company is happy to help out. Their interest charge is only 3% per month.

If Miss Haines paid back the $790 within a month, about how much interest would be have to pay?



Here's one way to make a reasonable estimate.

$790 is about $800

1% of $800 is $8

3% of $800 is $24

This estimation method is called THE ONE-PERCENT METHOD

Class Exercises

1. Another loan company advertises loans at 2-1/2% per month.

   a. Use the 1% method to estimate the interest on a $790 loan.
   b. About how much interest would you have to pay on a $1210 loan?

2. Mr. Gomez pays professional dues of 1/2% of his annual salary. About how much does he pay in dues if his annual salary is $19,100? (Use the 1% method)

3. Mrs. Jones is playing some "Guess My Number" games with her class. See how close you can guess the numbers Mrs. Jones is thinking of.

   a. 1% of it is 5.
   b. 1% of it is 7.
   c. 1% of it is 29.
   d. 1% of it is 73.

   (How large is her number? In other words, how much is 100% if 1% of it is 5?)

4. See how close you can "Guess My Number."

   a. 2% of it is 8.
   b. 3% of it is 6.
   c. 5% of it is 35.
   d. 8% of it is 24.

   (First find 1%; then 100%)

CLASS EXERCISES ANSWERS

1. a. $19 to $20 ($19.75) b. $30 to $31 ($30.25)
2. $90 to $100 ($95.50)
3. a. 500 b. 700 c. 2900 d. 7300
4. a. 400 b. 200 c. 700 d. 300

Mathematics teaching objectives:

- Determine approximate answers to a variety of percent word problems.
- Use rounding and mental arithmetic in making estimates.
- Use fractional percents in solving word problems.

Problem-solving skills pupils might use:

- Record appropriate values in a table.
- Create other problems which can be solved by certain procedures.
- Solve an easier but related problem.

Materials needed:

- None

Comments and suggestions:

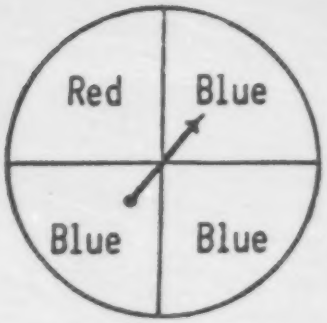
- The method of finding factional percents is easier for most pupils if the process used does not require the conversion of the percent to a decimal. The one-percent method does not require conversion to a decimal but does require the ability to divide by 100.

- Some of the word problems require pupils to find the 100% number when a percent of the number is given. (See problems 3 and 4 in the Class Exercises and problem 5 in the Exercises.) This difficult percent problem type usually can be solved rather easily by using the one-percent method.

- Pupils should be able to proceed independently on the Exercises after being introduced to the one-percent method using a group discussion approach to the introduction and the Class Exercises.

METHOD THREE -- PERCENTS AND FRACTIONS

Mr. Bransom gave each of four students a spinner exactly like the one pictured. He asked each of them to spin it a total of 100 times. Here are the results.



Spinner A

Lonnie - Red 23 times
Mike - Red 53 times
Mark - Red 49 times
Tammy - Red 26 times

Do you think that these results are reasonable?

Is it possible that Mr. Bransom might have "fixed" a couple of the spinners? If so, which ones?

If the spinners had not been fixed, then

- red should have occurred about 1/4 of the time.
- 1/4 of the time means about 25 times out of 100 (25%).

Fractions are very useful in making estimates in problems involving percent. We will call this estimation method the FRACTION METHOD.

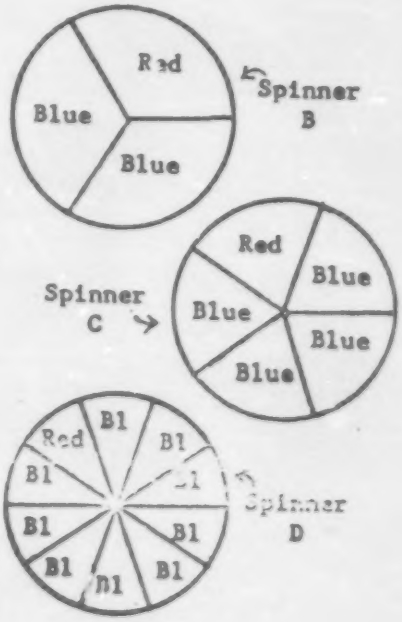
Class Exercises

1. If the spinners were not fixed,

   a. about what fraction of the time should a blue occur?
   b. about what percent of the time should a blue occur?

2. Assume that the spinners at the right are not fixed. Complete the chart below.

Spinner	Fraction	% (Red)	Fraction (Blue)	% (Blue)
A	1/4	25%	3/4	75%
B				
C				
D				



Mathematics teaching objectives:

- Determine approximate answers to a variety of percent word problems.
- Use rounding and mental arithmetic in making estimates.
- Use fraction equivalents in solving percent problems.

Problem-solving skills pupils might use:

- Record appropriate values in a table.
- Solve an easier but related problem.
- Create other problems which can be solved by certain procedures.

Materials needed:

- None

Comments and Suggestions:

- Estimates for answers to certain percent problems can be made quickly if the fractional equivalents for certain percents are nown. Especially useful are the percent equivalents for halves, thirds, fourths, fifths, and tenths. Pupils also will need to make mental calculations such as $\frac{1}{3}$ of 90 or $\frac{3}{4}$ of 60.

- Several of the word problems require the pupils to find the percent when the "part and whole" are given. This type was not included in the two previous lessons. All three types are included in this lesson (see introduction).

- Spend some classtime with the percent problems pupils make up. Often some of them show much imagination!

3. Many students at Lincoln School were absent during a flu epdimec. The total enrollment of Lincoln is 591. For each day, determine about how many students were absent.

Day	% Absent	Number of Absences (Estimate)
Monday	47%	
Tuesday	34%	
Wednesday	26%	
Thursday	19%	
Friday	11%	

4. Debbie tries to save about 75% of her earnings. About how much does she save each month?

Month	Earnings	Amount Saved (Estimate)
June	$79	
July	$61	
August	$98	

CLASS EXERCISE ANSWERS

1. a. $\frac{3}{4}$ b. 75%
2. b. $\frac{1}{3}$, 33$, $\frac{2}{3}$, 67% Spinner B
   c. $\frac{1}{5}$, 20%, $\frac{4}{5}$, 80% Spinner C
   d. $\frac{1}{10}$, 10%, $\frac{9}{10}$, 90% Spinner D
3. Monday 275 to 300 (278)
   Tuesday 200 to 225 (201)
   Wednesday 150 to 175 (154)
   Thursday 110 to 125 (112)
   Friday 60 to 70 (65)
4. June $59 to $60 ($59.25)
   July $45 to $46 ($45.75)
   August $73 to $75 ($73.50)

ESTIMATION WITH ANY OF THREE METHODS

GIGANTIC SALE!
All items 25% off

About how much would save on a color T.V. which normally costs $395.95? Here are three different estimation methods that can be used.

Meaning of Percent Method	One-Percent Method	Fraction Method
25% means $25 for every $100 or $100 for every $400	1% of $400 is $4 25% is $100	25% is $\frac{1}{4}$ $\frac{1}{4}$ of $400 is $100

Use any method you wish to make your estimates.

SPENDLESS WAS HAVING A SALE.

Give the approximate discount on each item.

Item	Cost	Percent Discount	Approximate Discount
Radio	$ 89.98	10%	
Calculator	$ 79.00	15%	
Watch	$ 99.00	12%	
T.V.	$379.00	20%	
Bicycle	$135.00	5%	
Sleeping bag	$ 49.95	50%	
Tennis Racket	$ 59.99	25%	
Jacket	$ 69.50	30%	

Mathematics teaching objectives:

- Use rounding and mental arithmetic in making estimates with percents.
- Review various methods for estimating percent problems.

Problem-solving skills pupils might use:

- Solve an easier but related problem.
- Solve a problem using a different method.
- Reason from what you already know (deduce).

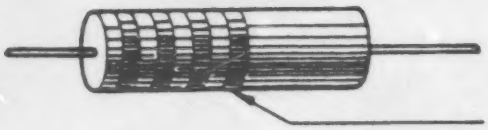
Materials Needed:

- None

Comments and suggestions:

- Since the main purpose of this lesson is to review the percent estimation procedures introduced in the first three lessons, begin the class by giving attention to the comparison of these procedures in the chart shown at the beginning of the lesson. Present other percent problems to the class and elicit from them the information needed to make a chart showing the three different methods.
- After pupils have worked several of the problems individually, spend several minutes having pupils indicate what procedures they used in working the problems.

USE OF PERCENT IN RESISTOR TOLERANCE



Tolerance band:
gold 5%
silver 10%
no band 20%

COMMENT

Percents are used in many applications. Resistor color codes are used to indicate resistor tolerances. Discussion of this area can help to introduce the concept of percent.

ACTIVITY

Help students learn to read resistor color codes and interpret percentages at the same time. There are usually three or four bands on carbon resistors. The fourth band indicates resistor tolerances. Many circuits can tolerate a wide variation of values. Some can use a particular component that is in error as much as plus or minus 20%. For example, a circuit that called for a resistor of 100 ohms can tolerate a resistor that can be as low as 80 ohms or as high as 120 ohms.

Emphasize that when percent is used, the comparison is expressed as a ratio between some number and 100. Help students calculate the actual range of ohms for the tolerance bands in the resistor at the top of the page.

SELLING ON CONSIGNMENT

COMMENT

You can provide students with a meaningful way to calculate percentage by having them figure out the commission charge on a consignment sale of an automobile.

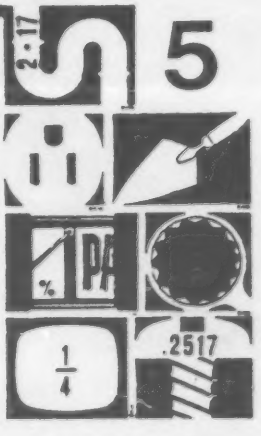
ACTIVITY

- First have the student determine the sale price of a car.
- Then direct the student to a commission fee chart (an example is shown below).
- Have student student calculate the commission fee for their car sale.

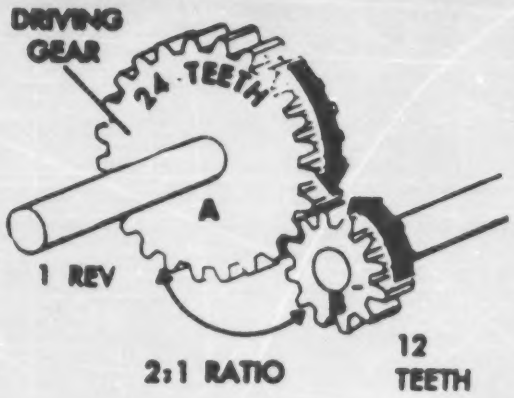
Commission Fee Chart

	$ Value of Car			
	0 - 4,999	5,000 - 19,999	+ 20,000	Maximum Fee
Commission Fee %	7%	6.5%	5%	5,000

conversions



The ability to read and interpret tables, graphs and charts is a necessary basic skill needed for functioning on today's society. However, if examples used are not related to experiences in which the student is involved, the examples will become meaningless drill.



Concept of Conversion

Often it is necessary to convert a fraction to a decimal, a decimal to a percent, one unit of measure to another unit of measure. Real-world applications require conversions but rely heavily on tables, graphs, and charts for those conversions. The concept of conversion is based on an understanding of ratio and proportion. A ratio is a mathematical means of comparing two quantities. A proportion is a statement of equality of two ratios. Skill in solving proportions accompanies estimation and approximation in conversions. Skill in solving proportions is often required when using tables, graphs, and charts for finding the conversion needed.

Graphs, tables and charts are some of the most useful forms for interpreting data and displaying information. Charts and tables provide specific information to the user. Of the variety of graphs -- picture, circle, bar, broken line -- each type has a specific purpose, e.g. bar graphs represent discrete information and allow comparison of amounts.

Skills

1. Concept of ratio and proportion
2. Conversion among common-based units
3. Reading and drawing conclusions from simple graphs, tables, and charts
4. Condensing numerical information into a meaningful display using tables, graphs, or charts

Pretest Ideas

One means of assessing skills in conversions and making charts also gives information about the student's conceptual understanding of the fractional, decimal and percent operations. Have the students create a conversion chart of fractions often used with decimal and percent equivalents. For many vocational areas, a chart from zero to one in sixteenth increments is most useful. Some areas use thirty-seconds and sixty-fourths. Adjust the activity for your area. Allow the students flexibility in developing a chart design. Also, allow the students to use calculators in making the conversion. If calculators are not allowed, the assessment may be changed to an assessment of the student's ability in the division operation.

An example of a type which might be created is:

Common Fractional Equivalents

Fraction	Decimal	Percent
0	0.0	0%
1/16	0.0625	6.25%
2/16 = 1/8	0.125	12.25%
3/16	0.1875	18.75%
.		
.		
.		
1.0	1.0	100%

COMMENT

This activity illustrates compression ratio. Use of this activity can demonstrate the concept of ratio.

If you had 1 quart [0.95 L] of air and compressed it to ¼ cup [0.12 L], you would compress the air to one-eighth of its original volume.

ACTIVITY

Your presentation might sound like this:

> The amount that the mixture of air and gasoline vapor is compressed is called the compression ratio.
>
> In a modern engine, the air-fuel mixture is compressed into one-eighth or one-ninth of its original volume. That is like taking 1 quart of air and squeezing it down to less than ¼ cup.
>
> [Now bring out your clear plastic 1 quart container and 1 cup measuring container. Demonstrate.]
>
> If you squeezed the mixture from 1 quart to ¼ cup, you would have a compression ratio of 8:1. There are 8 half-cups in 1 quart. When you compress the quart, which is 8 half-cups, into 1 half-cup, you have gone from 8 down to 1. That is, you have compressed the mixture down from 8 to 1. So, the compression ratio is 8 to 1. Usually, the ratio is shown as 8:1. You read this as "8 to 1."
>
> [Ask your students to describe other practical examples of ratios.]

USING PROPORTIONS FOR CONVERSIONS

COMMENT

Often students are given formulas or rules to help make conversions. However, they soon forget the rules or confuse the process. "Do I multiply by 2.5 or divide?" Developing an understanding for conversions requires an understanding of proportions. Be sure to use dimensions in the proportions.

EXAMPLE:

Problem: Convert 55 mm to inches

$$\frac{55 \text{ mm}}{x \text{ inches}} = \frac{25 \text{ mm}}{1 \text{ inch}}$$

Read: "55 millimeters is to 'how many' inches as 25 millimeters is to 1 inch"

Solution: (55mm) (1 inch) = (25 mm) (x inches)

$$\frac{(55 \text{ mm})\ (1 \text{ inch})}{25 \text{ mm}} = x \text{ inches}$$

2.2 inches = x inches

ACTIVITY

Using the chart, Comparing the Most Common Measurement Units, sh w students "why" the rule is given on the right hand side of the chart. Use proportions plus dimensions.

Have students explain some of the other entries in the chart by demonstrating the proportion to make the conversion.

Comparing the Most Common Measurement Units

Approximate conversions from Customary to metric and vice versa.

	When you know:	You can find:	If you multiply by:
LENGTH	inches	millimeters	25
	feet	centimeters	30
	yards	meters	0.9
	miles	kilometers	1.6
	millimeters	inches	0.04
	centimeters	inches	0.4
	meters	yards	1.1
	kilometers	miles	0.6
AREA	square inches	square centimeters	6.5
	square feet	square meters	0.09
	square yards	square meters	0.8
	square miles	square kilometers	2.6
	acres	square hectometers (hectares)	0.4
	square centimeters	square inches	0.16
	square meters	square yards	1.2
	square kilometers	square miles	0.4
	square hectometers (hectares)	acres	2.5
MASS	ounces	grams	28
	pounds	kilograms	0.45
	short tons	megagrams (metric tons)	0.9
	grams	ounces	0.035
	kilograms	pounds	2.2
	megagrams (metric tons)	short tons	1.1
LIQUID VOLUME	ounces	milliliters	30
	pints	liters	0.47
	quarts	liters	0.95
	gallons	liters	3.8
	milliliters	ounces	0.034
	liters	pints	2.1
	liters	quarts	1.06
	liters	gallons	0.26
TEMPER-ATURE	degrees Fahrenheit	degrees Celsius	5/9 (after subtracting 32)
	degrees Celsius	degrees Fahrenheit	9/5 (then add 32)

CONVERTING DRILL SIZES

COMMENT

Once students have acquired skill with decimals, ratio, proportion, and percent, conversion tables may be introduced. A useful conversion table needed for many vocational applications is one which converts drill sizes from number to fraction to decimal form.

ACTIVITY

Demonstrate the use of the chart (format, how to use, structure).

Help students use this chart in conjunction with the previous chart. Have students use calculators to check the conversions in this chart.

Give students specific problems which require the use of the data in the chart.

DRILL SIZE

Drill sizes are expressed by the following series:

NUMBERS - #80 to #1 (0.0135-in. to 0.2280-in. diameters).

LETTERS - A to Z (0.234-in. to 0.413-in. diameters).

INCHES AND FRACTIONS THEREOF - 1/64-in. to 3-1/2-in. diameters.

METRIC - 3 mm (0.1181-in. diameter) to 76 mm (2.9921-in. diameter).

The DRILL SIZE CHART, Fig. 34-9, will give an idea of this vast array of drill sizes.

HOW TO MEASURE DRILLS

Most drills, with the exception of small number drills, have the diameter stamped on the shank. These figures frequently become obliterated with use and it is almost impossible to determine the drill diameter without measuring.

Inch	Mm.	Wire Gage	Decimals of an Inch
		80	.0135
		79	.0145
1/64			.0156
	.4		.0157
		78	.0160
		77	.0180
	.5		.0197
		76	.0200
		75	.0210
	.55		.0217
		74	.0225
	.6		.0236
		73	.0240
		72	.0250
	.65		.0256
		71	.0260
	.7		.0276
		70	.0280
		69	.0293
	.75		.0295
		68	.0310
1/32			.0313
	.8		.0315
		67	.0320
		66	.0330
	.85		.0335
		65	.0350
	.9		.0354
		64	.0360
		63	.0370
	.95		.0374
		62	.0380
		61	.0390
	1		.0394
		60	.0400
		59	.0410
	1.05		.0413
		58	.0420
		57	.0430
	1.1		.0433
	1.15		.0453
		56	.0465

Inch	Mm.	Wire Gage	Decimals of an Inch
3/64			.0469
	1.2		.0472
	1.25		.0492
	1.3		.0512
		55	.0520
	1.35		.0531
		54	.0550
	1.4		.0551
	1.45		.0571
	1.5		.0591
		53	.0595
	1.55		.0610
1/16			.0625
	1.6		.0630
		52	.0635
	1.65		.0650
	1.7		.0669
		51	.0670
	1.75		.0689
		50	.0700
	1.8		.0709
	1.85		.0728
		49	.0730
	1.9		.0748
		48	.0760
	1.95		.0768
5/64			.0781
		47	.0785
	2		.0787
	2.05		.0807
		46	.0810
		45	.0820
	2.1		.0827
	2.15		.0846
		45	.0860
	2.2		.0866
	2.25		.0886
		43	.0890
	2.3		.0906
	2.35		.0925
		42	.0935

Inch	Mm.	Wire Gage	Decimals of an Inch
3/32			.0938
	2.4		.0945
		41	.0960
	2.45		.0966
		40	.0980
	2.5		.0984
		39	.0995
		38	.1015
	2.6		.1024
		37	.1040
	2.7		.1063
		36	.1065
	2.75		.1083
7/64			.1094
		35	.1100
	2.8		.1102
		34	.1110
		33	.1130
	2.9		.1142
		32	.1160
	3		.1181
		31	.1200
	3.1		.1220
1/8			.1250
	3.2		.1260
	3.25		.1280
		30	.1285
	3.3		.1299
	3.4		.1339
		29	.1360
	3.5		.1378
		28	.1405
9/64			.1406
	3.6		.1417
		27	.1440
	3.7		.1457
		26	.1470
	3.75		.1476
		25	.1495
	3.8		.1496
		24	.1520
	3.9		.1535
		23	.1540

Inch	Mm.	Wire Gage	Decimals of an Inch
5/32			.1563
		22	.1570
	4		.1575
		21	.1590
		20	.1610
	4.1		.1614
	4.2		.1654
		19	.1660
	4.25		.1673
	4.3		.1693
		18	.1695
11/64			.1719
		17	.1730
	4.4		.1732
		16	.1770
	4.5		.1772
		15	.1800
	4.6		.1811
		14	.1820
		13	.1850
	4.7		.1850
	4.75		.1870
3/16			.1875
	4.8		.1890
		12	.1890
		11	.1910
	4.9		.1929
		10	.1935
		9	.1960
	5		.1969
		8	.1990
	5.1		.2008
		7	.2010
13/64			.2031
		6	.2040
	5.2		.2047
		5	.2055
	5.25		.2067
	5.3		.2087
		4	.2090
	5.4		.2126
		3	.2130
	5.5		.2165
7/32			.2188
	5.6		.2205
		2	.2210
	5.7		.2244
	5.75		.2264
		1	.2280
	5.8		.2283

Decimal equivalents of tool sizes.

TOP SPEED, OVERALL GEAR RATIO CALCULATOR

COMMENT

Tables, graphs and charts are used widely in vocational applications. Students need to be given work with these forms of data presentations. Use this activity as a practical experience in interpreting information through the use of scales.

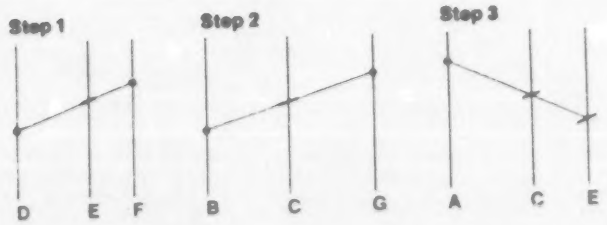
ACTIVITY

Given: Transmission ratio, Scale F; Rear end ratio, Scale D; R.P.M. Scale G: Tire diameter (in inches) Scale B

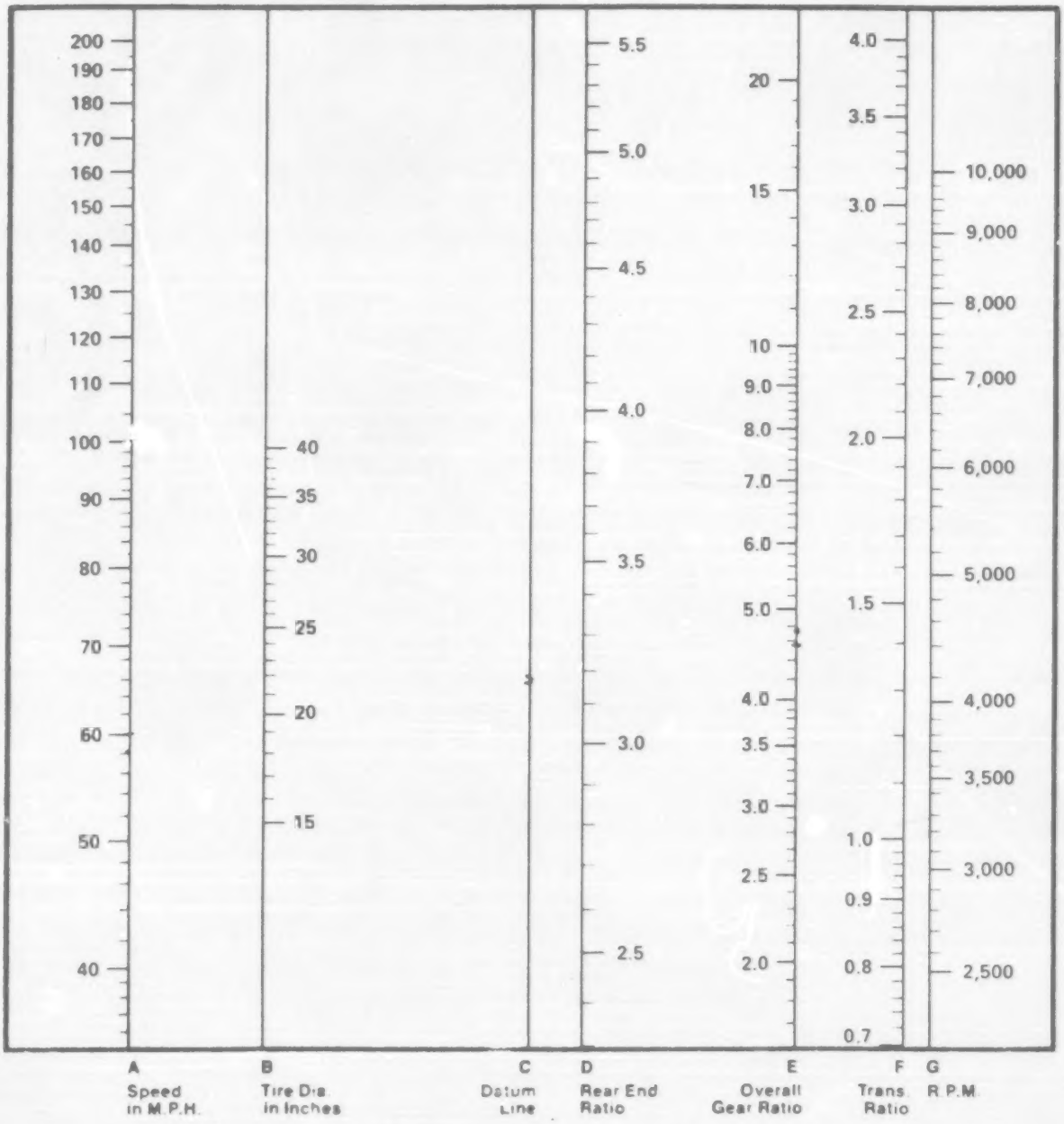
Find: Overall gear ratio, Scale E; Speed, Scale A

Procedure:

1. Connect known points on Transmission, Scale F and Rear end, Scale D. Mark point at Overall gear ratio, Scale E.
2. Connect known points on Tire diameter, Scale B and R.P.M., Scale G. Mark point on Datum line, Scale C.
3. Connect two marked points (Scales C and E) and extend line through Speed, Scale A.



TOP SPEED, OVERALL GEAR RATIO CALCULATOR



USING A GRAPH IN AUTOMOTIVE APPLICATIONS

COMMENT

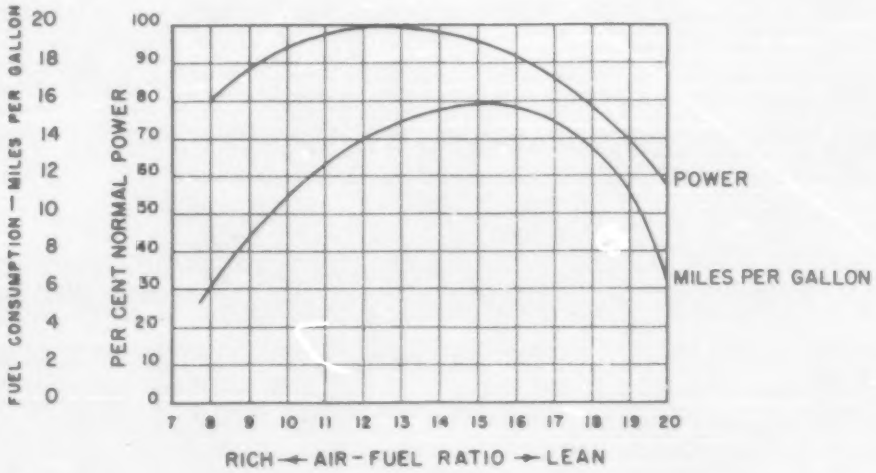
Here are two graphing activities found in *Swiggins, Boyce H., Practical Problems in Mathematics for Automotive Technicians. Delmar Publishers, 1972.*

Help students understand graph through questions.

ACTIVITY 1 *(page 108)*

Since gasoline will ignite only when mixed in certain proportions with air, it is the function of the carburetor of an automobile engine to mix air with gasoline in the proper proportions for combustion. The ratio of pounds of air admitted to the engine, to the pounds of gasoline to be mixed with it, is known as Air-Fuel Ratio.

With the usual gasoline, a mixture of fifteen pounds of air with one pound of gasoline insures complete combustion. This ideal Air-Fuel Ratio of 15 to 1 is not desired, however, in general practice even though most economical in gasoline consumption, because the gasoline engine does not develop maximum power at this ratio. The graph indicates that maximum power is obtained in the usual automotive engine with an Air-Fuel Ratio of 12.5 to 13.5 to 1. Since no great loss of power results when the mixture is over-rich, there is a tendency to set carburetors on the rich side -- and the owner pays for the wasted gas.



Using the graph, answer the following questions:

1. At what air-fuel ratio do we get the best number of miles per gallon of gasoline? _____

2. If too much air is present in the mixture used, what happens to the number of miles per gallon of gasoline? _____

3. Does it make much difference in the power whether we use a 10 to 1 or 15 to 1 air-fuel ratio? _____

4. What air-fuel ratio gives the maximum power? _____

5. Is the air-fuel ratio which gives the maximum power also the air-fuel ratio which gives the largest number of miles per gallon of gasoline used? _____

ACTIVITY 2 *(page 110)*

A test often used to determine whether a radiator is clogged requires measuring the quantity of water which flows through the radiator by gravity in a certain time. Standards have been determined for each car's radiator and any less water flowing through the radiator indicates clogging.

1939 Buick - 27 gallons per minute
1939 Chevrolet Master - 19½ gallons per minute
1938 Ford V-8 - 42½ gallons per minute
1939 Plymouth - 17½ gallons per minute

6. Make four graphs for the above radiators plotting seconds against gallons of flow.

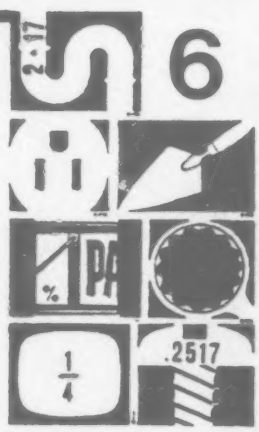
7. In a radiator test on a "39" Buick, a container was placed under the bottom radiator outlet for 10 seconds and 4 gallons of water were collected. Show your figures to prove that this radiator test did or did not indicate clogging.

8. A "39" Chevrolet Master was given the radiator test and 26 quarts of water were collected in 20 seconds. Does this test indicate clogging? _____

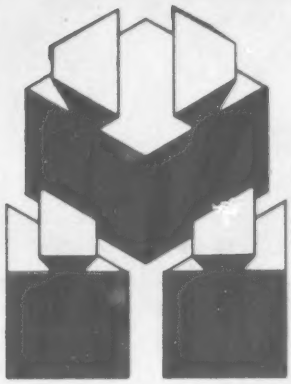
9. How many quarts should a container hold to be used for a "39" Plymouth radiator test if water is going to be collected for a 30 second test? _____

10. A Ford V-8 (85 h.p.) is to be given the radiator test. If a 5 gallon can is the largest container available, how many seconds should the test be run, assuming the radiator is not clogged? _____

geometry



Students should learn the geometric concepts to function in a three-dimensional world.



Concept of Geometry

Geometric shapes of various dimensions abound in the environment--both natural and human-made. Common objects such as seed pods, honeycombs, snowflakes, books, oatmeal boxes, windows, balls, dinner plates, and so on are some of our students' geometric models. Additional geometric concepts should be built on these basic observations. Geometry is developed by an intuitive approach in which students explore and experiment with materials to discover various geometric concepts.

Students live in a three-dimensional world. Therefore, their first geometric experiences should be with three-dimensional models. As they explore space figures, they also begin investigation of plane figures as they learn to consider just a surface of a space figure. All of this is done very informally. Then they are ready to consider lines and points, the building blocks of geometry. Finally they return, on a more abstract level, for additional exploration into the properties of plane figures and space figures.

This section contains sample activities that will help students discover geometric concepts.

Skills

Students should learn the geometric concepts they will need to function effectively in the three-dimensional world. Skills associated with geometry include:

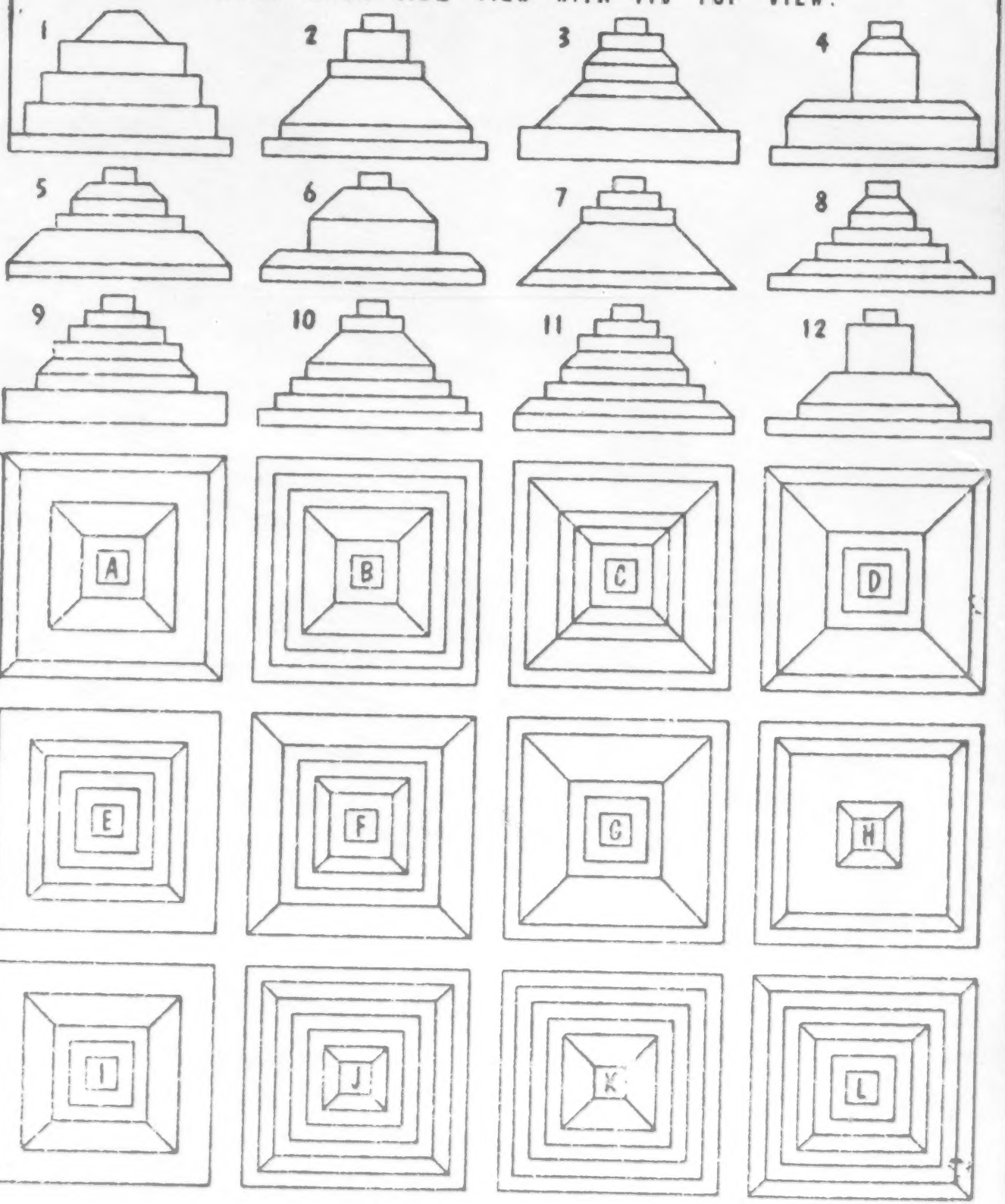
1. Visualization and intuition of geometric shapes and their properties.
2. Intuitive perspective of space, spacial relationships, and motion geometry.
3. Facility with concepts of parallel, perpendicular, area, and volume.
4. Recognition of similarities and differences among objects.

Pretest Ideas

Perception and visualization are particularly important in many vocational applications. One means of assessing the student's spatial perception is to use this set of exercises.

PROFILE PUZZLE

MATCH EACH SIDE VIEW WITH ITS TOP VIEW.



COOPERATION GAME

COMMENT

Use this game the help aid in spacial relationships with geometric figures.

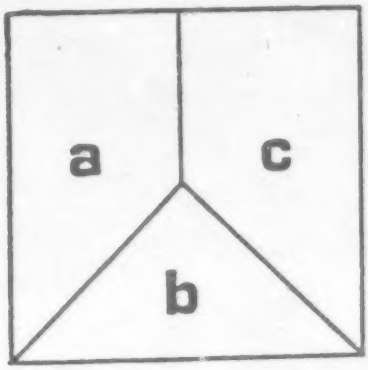
ACTIVITY

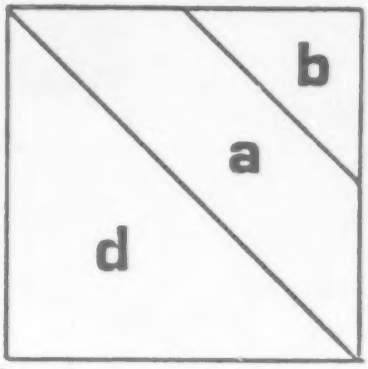
Divide students in groups of four. Give each student 3 pieces. When all the pieces are put together, they form 4 separate and equal squares. There are 3 rules to make the task a little more difficult. *Lawrence Hall of Science, University of California, Berkely.*

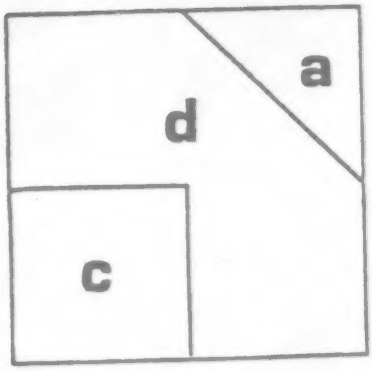
RULES:

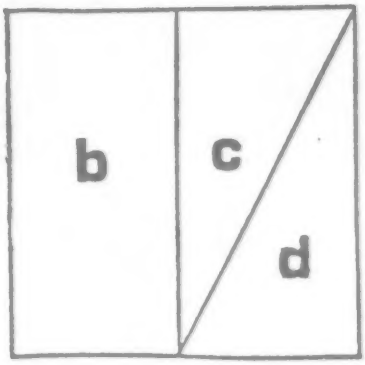
1. No talking
2. You may give a piece to another player but -
3. You may not take a piece.

Give student 1 all the A pieces, student 2 all the B pieces, student 3 all the C pices, and student 4 all the D pieces.







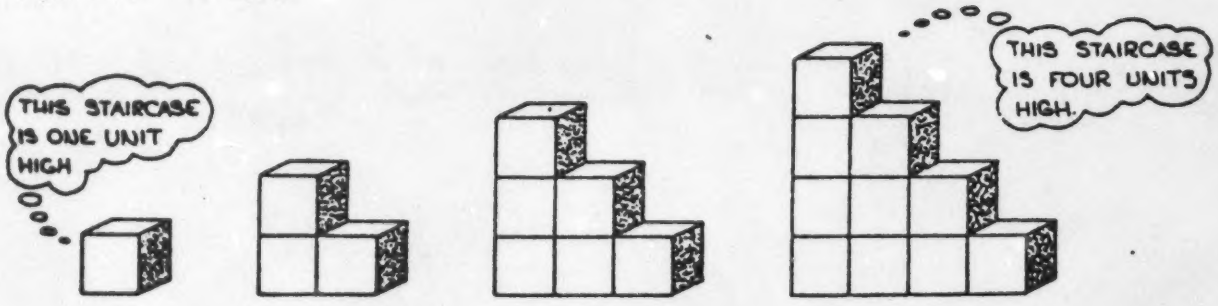


USING MODELS TO DEVELOP INTUITION AND PERSPECTIVE

Creative Publications, Palo Alto, California.

STAIRCASES

Materials: 36 cubes



1) How many cubes are needed to make each staircase above? Record your answer in the table below. You can build each staircase with cubes to check your answers.

2) Find the surface area of each staircase above. Be sure to count the faces on the bottom of the staircase. Record your answers in the table below. Again you can build the staircases with cubes to check your answers.

3) Complete the table. Use cubes to build each staircase. Do you see any patterns?

4) Challenge: If a staircase is 20 units high, how many cubes will it contain?

_____

What is the surface area of this staircase? _____ __

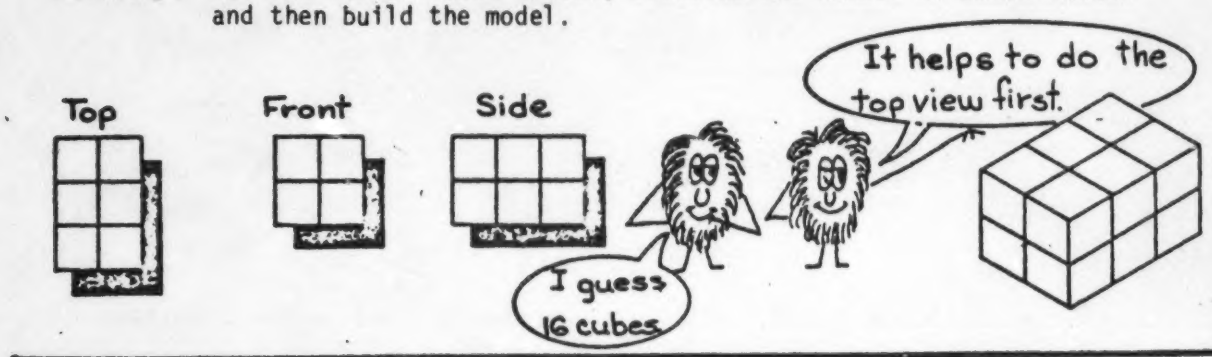
Weight of Staircase In Units	Number of Cubes	Surface Area in Square Units
1	1	6
2	3	14
3		
4		
5		
6		
7		
8		
9		
10		

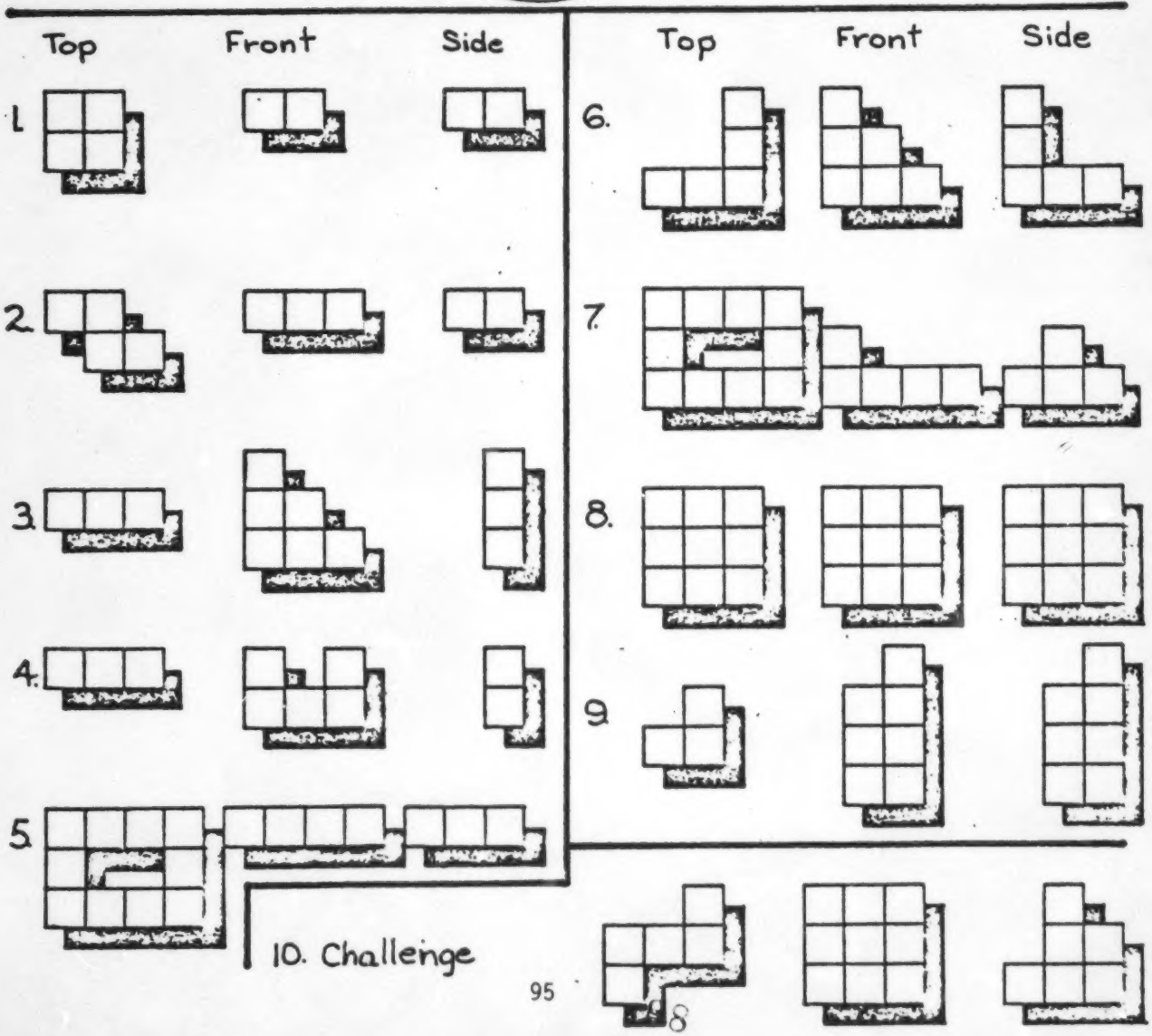
HOW WELL DO YOU STACK UP THIS TIME?

Creative Publications, Palo Alto, California.

Materials Needed: A set of cubes

Activity: Use the three views. First, estimate the number of cubes needed and then build the model.





Developing Spatial Imagination

All elements of design exist within space. Developing awareness of the dimensions of space, and of the relationship between lines and surfaces within a spatial framework is a general objective of drafting, and a prerequisite to design. Here's a way that you can modify a typical pictorial drawing problem to encourage your students to develop spatial imagination.

Give each student a drawing of a six-inch cube that is covered by a one and one-half-inch grid from which wires of various lengths are hung (Figure 1). Instruct the student to compose an arrangement of seven or eight rectangular boxes using this worksheet. The arrangement must (1) be visually pleasing in all three dimensions, (2) fit within the cube's area, (3) not touch any of the suspended wires, and (4) have all boxes at least partly visible in a resulting pictorial drawing.

Because the worksheet is a two-dimensional representation, the student must first imagine the space within the cube, then imagine boxes filling the space of the cube in a way that satisfies the requirements listed above. Early on, sketches prove helpful. Next, the student must make a three-view drawing of the arrangement. Finally, the three-view drawing can be used to draw or project a pictorial representation of the arrangement.

This assignment can help your students to explore three-dimensional spatial relationships, providing them with the understanding needed to design three-dimensional products. Change the worksheet with assignments to insure a variety of spatial environments. Use this approach for multi-view drawings, as well as pictorial drawings (obliques, isometrics, and perspectives).

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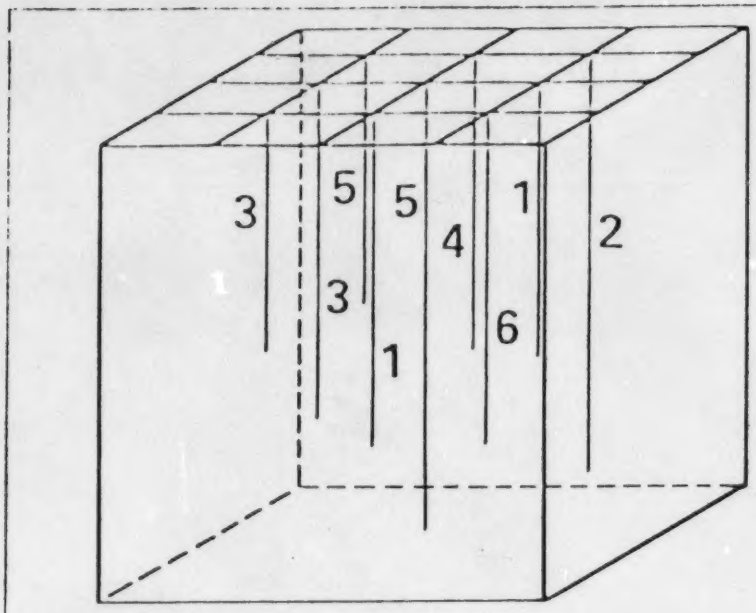


Fig. 1 – Cube from assignment sheet

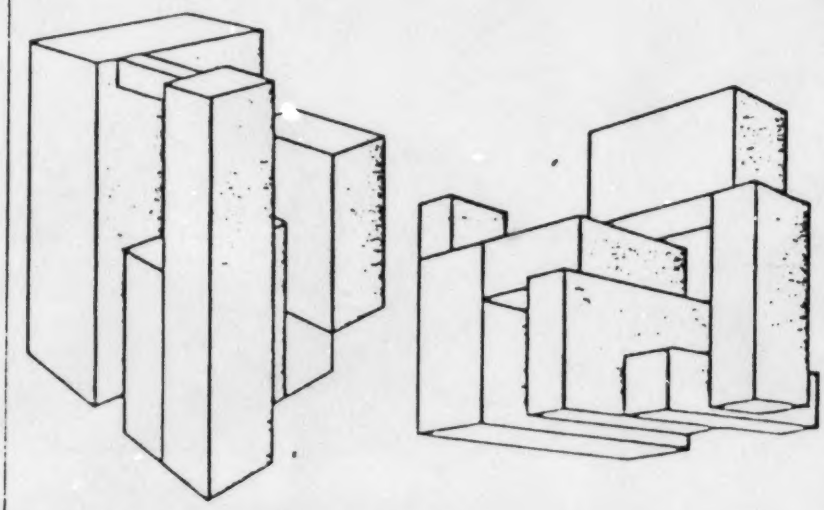
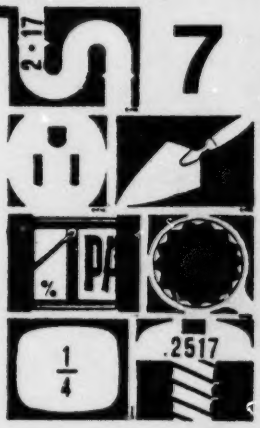


Fig. 2 – Sample solutions

more ideas



Problem solving is the process of applying previously acquired knowledge to new and unfamiliar situations. Solving word problems in texts is one form of problem solving, but students should be exposed to non-textbook problems. Problem solving strategies include:

- guess and test
- making lists
- building models
- simulating the situation
- asking questions

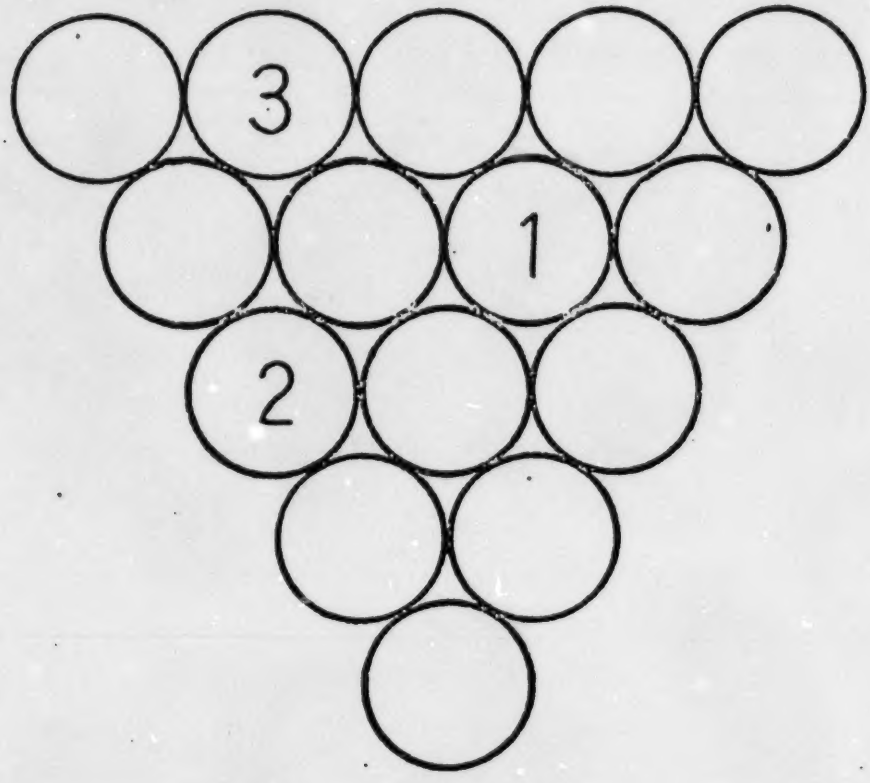
PROBLEM SOLVING

Problem solving is an important skill. This section contains a number of activities you can use to involve students in the process of problem solving. These activities include:

- logical reasoning
- organizing data
- using models
- prediction
- estimation

In order to maintain the emphasis on these skills allow students to use calculators whenever they are needed.

POOL PATTERNS



Oregon Skinny discovered some interesting ways to arrange pool balls. In one arrangement, each number can be determined by subtracting the two numbers immediately above.

Suppose Skinny tells you the location of the 1, 2, and 3 balls (see diagram above). Determine the location of the other balls.

EXTENSION

Skinny tried another arrangement. This time he tried to make each number equal to the sum of the two immediately above. How could you convince Skinny that this arrangement is impossible. (The 1, 2, and 3 balls do not have to be in the same location as in the diagram above.)

Lane County Math Project, Eugene, Oregon.

MATH USED IN JOBS

In this activity students will find some answers to the often asked question, "When are we ever gonna have to use this?"*

SKILLS: Ordering, Decision making, Working cooperatively, Estimating

TIME: 20 - 30 minutes

MATERIALS: Ranking sheets and answer sheets

DIRECTIONS:

Start

Discuss math skills

Student ranks math skills

Group ranks math skills

Give answers Score ranking sheets

Discuss

Stop

The students will guess which math skills are used most often in occupations. Explain to the students that the information was gathered by interviewing one hundred people in a wide variety of jobs to determine what kind of mathematics they actually use in their work. The 100 occupations are listed on the answer sheet. Hand out the ranking sheets listing the 10 math skills.

Working alone: The student's task is to rank the 10 math skills listed according to how many occupations use this skill. Place number 1 by the math skill used most often, number 2 by the skill used second most frequently, and so on through number 10, which is the math skill used the least.

Working in Small Groups: After students have completed the task, have them form groups of 3-5. Give each group a new ranking sheet; write group at the top of the sheet. They now have a second opportunity to rank these math skills. This time they will be working with a small group of people, and the group will be asked to reach a consensus on each item. A decision process is most productive if it can make use of the resources of the group and resolve conflicts in a creative manner.

When the groups are finished, have one member of each group score the group ranking. Individuals can score their own sheets for comparison with the group.

To score: Take the absolute value of the difference between the correct ranking and the one the group has given.

	group	correct	difference
Example: Fractions	2	5	3

Add all the differences for a total score.

Lawrence Hall of Science, University of California, Berkely.

Discussion: Ask whether any individual had a lower score (the lower the score the more accurate the ranking) than the group score. Discuss the dynamics within the group. Discuss the actual occupations and how the math skills may be used in each occupation.

EXTENSIONS: Have students interview people in various careers to find out what type of math they use in their field. Students can then make a similar activity based on the information they collected.

*This activity was developed from the work of Hal Saunders, junior high school math teacher, Santa Barbara, CA. The information was first published in an article, "When Are We Ever Gonna Have to Use This?" written by Hal Saunders for The Mathematics Teacher, January 1980. He states that the results should not be considered conclusive as only one representative of each occupation was interviewed.

Use of

fractions	____
statistics	____
calculators	____
formulas	____
decimals	____
averaging	____
ratio and proportion	____
estimation	____
per cent	____
statistical graphs	____

Use of

fractions	____
statistics	____
calculators	____
formulas	____
decimals	____
averaging	____
ratio and proportion	____
estimation	____
per cent	____
statistical graphs	____

MATH USED IN JOBS

Math Skill	% of the jobs which use this skill	Rank
decimals	100%	1
calculators	98%	2
per cent	97%	3
estimation	89%	4
fractions	88%	5
averaging	83%	6
statistical graphs	74%	7
ratio and proportion	77%	8
formulas	68%	9
statistics	65%	10

Occupations

Accountant
Accounting Systems Analyst
Administrator: Shopping Mall
Advertising Agent
Airline Passenger Service Agent
Airplane Mechanic
Airplane Pilot
Air Traffic Controller
Appraiser (Land)
Architect
Artist (Graphic)
Attorney
Auditor
Auto Mechanic
Bank Teller
Biologist (Environmental)
Carpenter
Carpet Cleaner
Cartographer
Chiropractor
Computer Programmer
Computer Systems Engineer
Contractor (General)
Controller (Hospital)
Counter Clerk (Building Materials)
Data Processor
Dentist
Dietician
Doctor (G.P.)
Draftsman
Economist
Electrician
Electronics Technician
(Civil) Engineer
(Electrical) Engineer
(Electronics) Engineer
(Industiral) Engineer
(Petroleum) Engineer
Environmental Analyst
Farm Advisor
Fire Prevention Officer
Fireman
Forestry Land Manager
Forestry Recreation Manager
Geologist (Environmental)
Highway Patrolman
Hydrologist
Income Tax Preparer
Insurance Agent
Insurance Claims Supervisor
Interior Decorator
Investment Counselor
Landscale Architect
Librarian
Machinist
Manager: Appliance Store
Manager: Temp. Employment Service
Marketing Rep. (Computers)
Masonry Contractor
Medical Lab Technician
Meteorologist
Motorcycle Sales & Repair
Navigator
Newspaper: Circulation
Newspaper: Production
Newspaper: Reporter
Nurse
Oceanographer (Biological)
Optician
Orthopedic Surgeon
Painting Contractor
Payroll Supervisor
Personnel Administrator
Pharmacist
Photographer
Physical Therapist
Plumber
Police Officer
Political Campaign Manager
Printer
Psychologist (Experimental)
Publishing: Order Manager
Publishing: Production Manager
Purchasing Agent
Radio Technician
Real Estate Agent
Roofer
Savings Counselor
Sheet Metal/Heating Specialist
Social Worker
Stock Broker
Surveyor
Technical Researcher
Title Insurance Officer
Travel Agent
T.V. Repair Technician
Urban Planner
Veterinarian
Waitress
Wastewater Treatment Operator

"When Are We Ever Gonna Have to Use This?"

HOW TO USE AND INTERPRET THIS CHART

1. This chart will give you two types of information. Read horizontally, it will show which of the 100 occupations sampled use each math topic. Read vertically, it will indicate all of the math topics used by each occupation.

2. The math topics range from basic arithmetic to second-year algebra and trigonometry. The specific breakdown of topics may vary from teacher to teacher. Note that the last group of topics includes use of the calculator, computer operation, computer programming, and higher math.

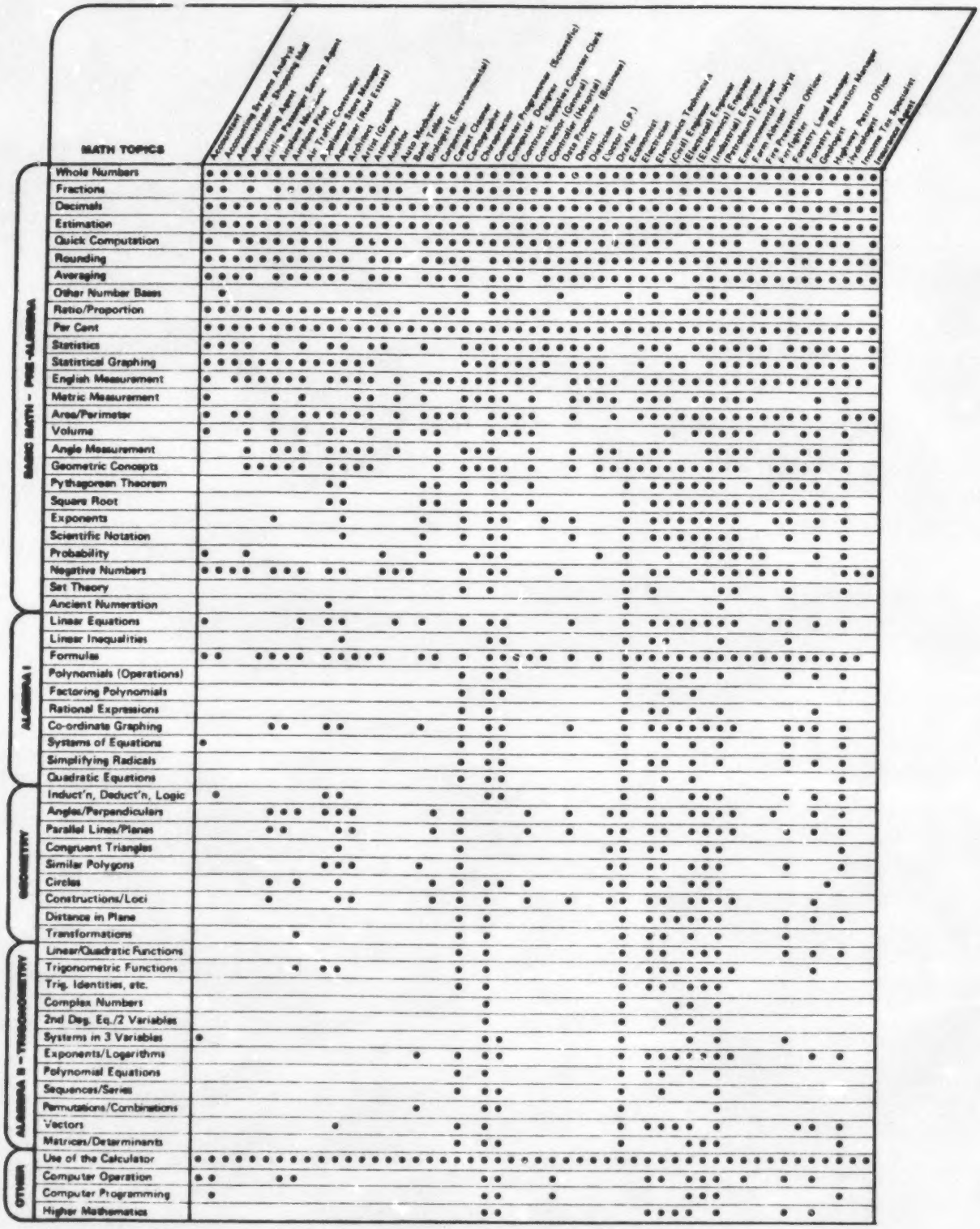
3. Keep in mind that the dots indicate actual on-the-job *usage* of particular concepts. To qualify for some occupations, students must take more mathematics than they will normally use in their work. For example, doctors, dentists, and veterinarians must have an extensive math background in case they become involved in bio-medical research. As the chart indicates, they use little more than algebra or geometry in their practices.

4. Emphasize to your students that the chart only represents a portion of the existing occupations in this country. If the chart shows only 7 or 8 people using a particular math topic, consider this to mean that 7% or 8% of all occupations would probably utilize this concept. This may amount to hundreds of different jobs.

5. Variations in math usage will exist among different people in the same occupation. These variations occur mainly because of different areas of specialization. However, other variations in math usage occur simply because certain individuals have, and make use of, a stronger math background. An attorney with a strong foundation in mathematics can take on cases of a highly technical nature. Sheet metal workers who know trigonometry are in much higher demand because the shop foreman will not have to perform calculations for them. A business manager who understands algebra can design formulas which will improve his efficiency and profit. In summary, mathematics is a powerful tool – a strong background will qualify you for more jobs and allow you to do almost any task more efficiently.

Note: This revised edition of the poster-chart differs slightly from the original and its reduction which appears in the book of word problems.

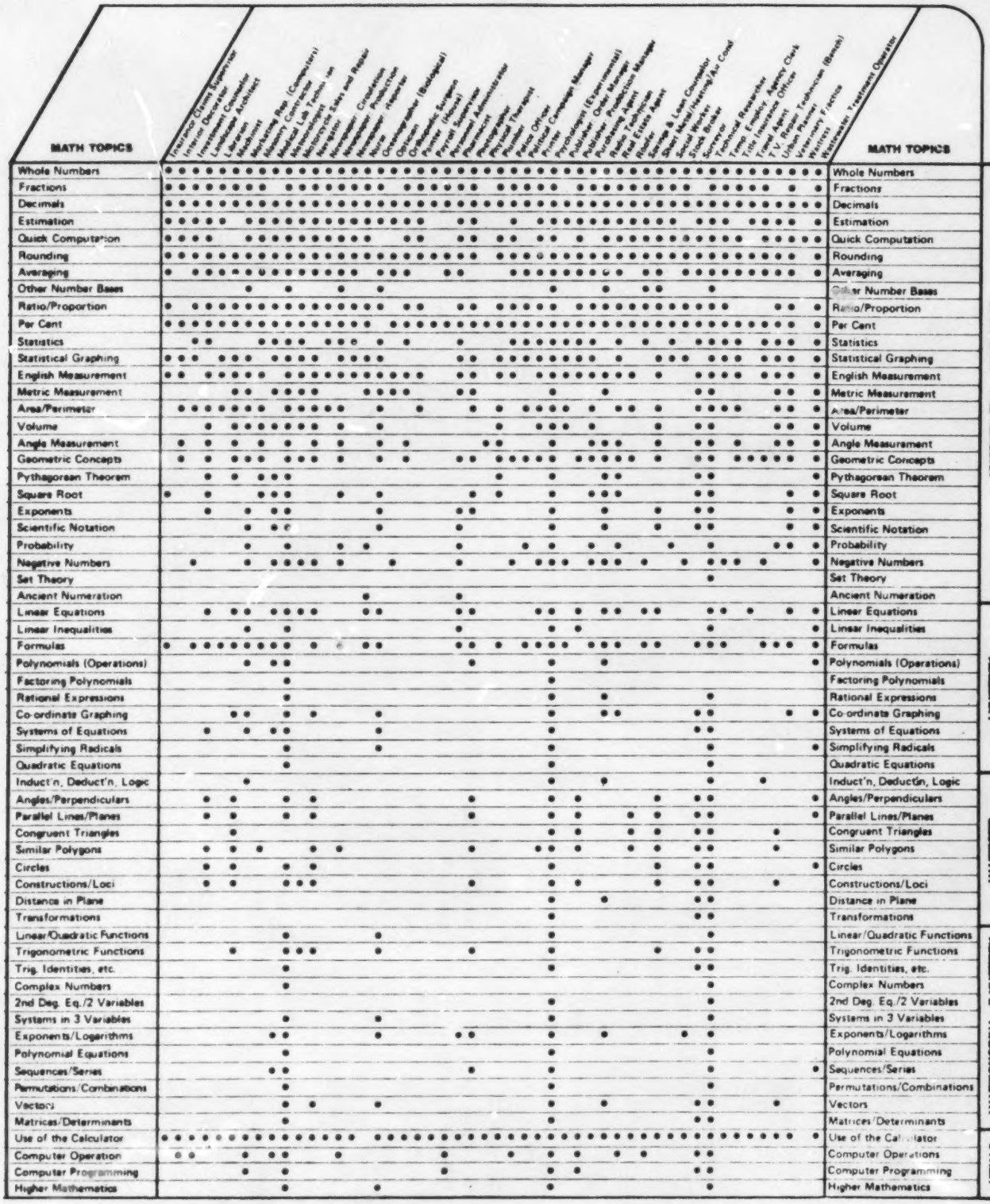
"When Are We Ever



HMS Publications - P.O. Box 5809 - Santa Barbara, CA 93108

110

Gonna Have To Use This?"



Second Edition Copyright © 1981, 1980 Hal Saunders

Calculate horsepower of an automobile engine.

Mathematics Involved

Common fractions, formulas

Application A

Find the approximate brake horsepower (BHP) of a Thunderbird V-8 engine that, at 4,600 r.p.m., registers 135 pounds at the end of a Prony brake arm 2 1/2 feet long.

Solution:

Find twice the product of π, the length of the arm in feet, the number of revolutions per minute, and the registered weight in pounds; then divide the result by 33,000, the number of foot-pounds per minute required to create one horsepower. BHP = $2\pi LWN/33{,}000$; BHP = 6.28 × 2 1/2 × 135 × 4,600 divided by 33,000; thus BHP = (approximately) 296 horsepower.

Application B

Find the taxable horsepower of the Thunderbird, which has a cylinder bore of 4.00". (Automobiles are taxed by horsepower in certain states.)

Solution:

When d = the diameter of bore, and N = number of cylinders, taxable horsepower (THP) is found as follows: THP = square of *d* multiplied by *N* divided by 2 1/2; THP = 4.00 × 4.00 × 8/2½ or THP = 256/5 or (approximately) 51 horsepower.

(NOTE: **The result above appears to be low in comparison to other computed horsepower figures; yet, for tax purposes, it affords a simplified method of comparing piston displacements of various automobiles.**)

Application C

Allowing for a 33% coefficient of friction (rendering potential horsepower unavailable for use), the Thunderbird, weighing 3,250 pounds, traveled 4.3 miles at uniform speed in five minutes. Calculate the horsepower, using these figures.

Solution:

When *d* = distance in feet, *W* = the number of pounds, and *t* = duration of the test in minutes, horsepower (HP) = $dW/33{,}000t$. HP = 22,704 × 67% of 3,250, divided by 33,000 × 5; HP = (approximately) 300 horsepower. (Note: Compare the results of each of the three methods with the specifications listed for the Thunderbird V-8: 300 maximum horsepower at 4,600 r.p.m.)

Calculate corresponding readings on centigrade and Fahrenheit scales.

Mathematics Involved

Formulas, ratios

Application

A thermostat installed in a Jaguar is to maintain an engine temperature of 185° F. The Jaguar's temperature gauge is calibrated according to the centigrade scale. Determine whether or not a reading of 84° C. on the Jaguar's gauge is satisfactory.

Solution:

(a) From freezing point to boiling point on centigrade scale (0° to 100°) is 100°. From freezing point to boiling point on Fahrenheit scale (32° to 212°) is 180°. Thus, comparing 100° to 180°, a ratio of 100/180 = 10/18, or 5/9, results. There are 5° on the centigrade scale for every 9° on the Fahrenheit scale. Divide 84° by 5, which gives 16 4/5 "sets". Then, (16 4/5) × 9° = 151 1/5°; add the 32° that were not compared; 151 1/5° added to 32° gives 183 1/5°. Reading is near 185° F.; satisfactory. (b) Use formula: F = 9/5 C + 32°; F = (9/5 × 84°) + 32° = 183 1/5°.

Compute amount of antifreeze mixture for adequate protection at various temperatures.

Mathematics Involved

Per cent, tables

Application A

Find the amount of permanent type antifreeze (Ethylene glycol) needed to provide protection down to 10° F. in a cooling system that holds four gallons. (Tables show 25% required at 10° F.)

Solution:

25% of 4 gallons = 1 gallon

Application B

Tables show 45% required for protection to —20° F. Figure the number of quarts necessary for cooling system described in *Application A*.

Solution:

45% of 4 gallons = 7.2 quarts; 2 gallons must be bought. (Mixture sold "by the gallon" or "by the quart.")

Calculate amount of material to be left on a turned shaft for finishing.

Mathematics Involved

Common fractions, decimal fractions, linear measurements

Application

A screwdriver handle is to be turned to a specified diameter of 1 5/16". (a) What measurements should the outside calipers be set to allow for 1/32" finish turning? (b) How many thousandths of an inch should the cross-feed screw be advanced to cut to the finished diameter? (Note: Most lathes are equipped with a graduated bushing on the cross-feed screw which will show in thousandths of an inch the movement of the cross slide.)

Solution:

(a) The calipers should be set to 1 5/16" + 1/32" or 1 11/32 inches. (b) The cross-feed screw should be advanced 1/2 of 1/32" or .01562". The actual advance would be .015" with allowance for hand polishing.

Other Applications

Tolerances for different classes of fits, reamer drilling

Calculate miles per gallon for gasoline used.

Mathematics Involved

Averages, decimal fractions

Application

In 1,000 miles of recorded driving, 324.3 in city traffic and the remainder in high speed open road travel, a car used, respectively, 23.5 and 32.7 gallons of gasoline. Find m.p.g. for (a) city driving, (b) open road travel, and (c) the entire 1,000 miles.

Solution:

Number of miles ÷ number of gallons = m.p.g. (a) 13.8 m.p.g. (b) (approximately) 20.7 m.p.g. (c) (approximately) 17.8 m.p.g.

Find speed in terms of average miles per hour.

Mathematics Involved

Averages, formulas

Application A

Find average speed in miles per hour of a racing car maintaining an average of 2.31 miles per minute.

Solution:

Miles per hour = 2.31 × 60; average speed = 138.6 m.p.h.

Application B

Compute the average speed of a car driven 203 miles in 3 1/2 hours.

Solution:

Miles per hour = 203 ÷ 3 1/2; average speed = 58 m.p.h.

Determine a specified efficiency of an automobile engine.

Mathematics Involved

Per cent

Application

An automobile, using one pound of gasoline mixed with 15 pounds of air, produces 20,000 B.T.U.'s (British thermal units). Losses of power occur as follows: cooling system, 20%; exhaust system, 50%; and friction, 5%. How many B.T.U.'s are actually used in powering the car? How efficient is the engine?

Solution:

Add 20%, 50%, and 5%; subtract 75% from 100%; 25% = 1/4; 1/4 of 20,000 = 5,000 B.T.U.'s used to power the car. The thermal efficiency of the engine under such circumstances is 25%.

Other Applications

Mechanical efficiency, volumetric efficiency, unusual friction loss

Determine error in readings shown by speedometer and odometer with change in tire size.

Mathematics Involved

Circumferences, ratios

Application A

Wheels with 7.50 x 14 tires are exchanged for wheels with oversized tires, 8.00 x 15. Determine distance traveled by automobile for every 100 miles indicated by the odometer.

Solution:

Odometer is governed by revolution of wheel. Circumference of wheel specified = $\pi \times 29''$. Circumference of wheel with oversize tire = $\pi \times 31''$. Ratio of oversize circumference to specified circumference is equal to ratio of 31 to 29. Miles traveled has the same ratio to miles indicated as 31 has to 29. Multiply both ratios in this proportion by 100. Then, miles traveled = 3,100/29 or 106.9. The car travels 106.9 miles for every 100 miles indicated.

Application B

Calculate the speed in miles per hour when unadjusted speedometer indicates 55 miles per hour.

Solution:

Let r = actual rate of travel; apply relationship found in *Application A*. Then, $r : 55 :: 31 : 29$. Multiply both ratios by 55. Now, $r = 31 \times 55$ divided by 29; $r = 58.79$; the automobile is moving at a speed of approximately 59 m.p.h. when 55 m.p.h. is indicated.

Application C

Calculate the error as a per cent of the reading.

Solution:

The error of 6.9 miles, as found in *Application A*, compared to the reading of 100 miles indicates an error of 6.9%. The error of 3.79 m.p.h., as found in *Application B*, compared to the reading of 55 m.p.h. results in a ratio of 379/5500, or .069. This error, also, is 6.9%.

Find total length of a steel bar when a series of dimensions are known.

Mathematics Involved

Common fractions

Application

Find the length of a turned shaft with stepped-down diameters at intervals of 6 9/32", 4 1/2", and 3 3/4".

Solution:

Add 6 9/32" + 4 1/2" + 3 3/4" = 14 17/32".

Determine distance between centers of a series of equally spaced holes in a steel bar.

Mathematics Involved

Common fractions, decimal fractions, linear measurements

Application

Calculate the distance between the centers of seven holes to be drilled an equal distance apart in a steel bar. The length of the bar is 2' 4" and the end holes are located 2 1/4" from the ends.

Solution:

Sketch and dimension the proposed layout of holes. Six equal spaces are to be marked in the 23 1/2" length (28" − 4 1/2"). 23 1/2" ÷ 6 = 3.917 inches. Determine the nearest rule dimension (64ths) of the decimal fraction. .917 × 64 = 58.688 or $\frac{59}{64}$ inches. Note: A table of decimal fractions and common fractions equivalents provide appropriate rule dimensions.

Determine time needed to charge a battery.

Mathematics Involved

Common fractions, formulas

Application

A hydrometer test shows that a 120-ampere-hour storage battery is about half-charged. How long must it be charged at 40 amperes to become fully charged?

Solution:

Read "about half-charged" as "60 amperes needed"; then time = amperes needed ÷ amperes per hour; time = (approximately) 1 1/2 hr.

Determine missing dimension from an over-all series of dimensions.

Mathematics Involved

Common fractions

Application

Find the head thickness of a cap screw with a total length of 59/64" and a screw length of 5/8".

Solution:

Subtract the screw length from the total length.

$$\frac{59''}{64} - \frac{5''}{8} = \frac{19''}{64}.$$

Other Applications

Parallel line development for sheet metal layout, blueprint reading

Find secondary voltage in a given circuit when number of primary and secondary windings of coils are known.

Mathematics Involved

Formulas, ratios

Application

A 12-volt ignition coil has a 120-turn primary coil and a 200,000-turn secondary coil. Find the secondary voltage of this coil.

Solution:

Primary voltage has the same ratio to secondary voltage as the number of turns in primary coil has to the number of turns in secondary coil; primary voltage = 12, primary N = 120, and secondary N = 200,000; secondary voltage = E_s. The $12/E_s$ as $120/200{,}000$; $120 \times E_s = 12 \times 200{,}000$, or $120 \times E_s = 2{,}400{,}000$; $E_s = 20{,}000$ volts.

Calculate amount of hydraulic pressure on brake drum.

Mathematics Involved

Ratios

Application

Find amount of pressure exerted on the brake drum by both brake shoes when a pressure of 150 pounds is applied to a brake pedal having a mechanical advantage of 5. The area of the master cylinder piston is 1 square inch and area of each wheel cylinder piston is 2 square inches.

Solution:

Pressure on brake drum = pressure applied × mechanical advantage × area of master cylinder piston × area of wheel cylinder pistons × number of shoes. Pressure on brake drum = 150 × 5 × 2 × 2 = 3,000 pounds. (Master cylinder of 1 sq. in.; multiplying by 1 does not change numbers.)

Determine size of each wrench in a specified set of wrenches.

Mathematics Involved

Common fractions

Application

What size sockets would be in a 1/2" drive socket wrench set 1/2" to 1" by 16ths?

Solution:

A "set" includes 1/2", 9/16", 5/8", 11/16", 3/4", 13/16", 7/8", 15/16" and 1".

Figure ratio of acid to water in an etching solution.

Mathematics Involved

Liquid measurements, ratios

Application

Prepare a nitric acid solution for etching a copper serving tray.

Solution:

Determine standard ratio used in shop practice (2 parts water to 1 part acid). Measure 2 parts of water and pour into container. Measure 1 part of nitric acid and add to water.

Other Applications

Soldering fluxes, pickling solutions

Determine specific gravity of an electrolyte in a battery under varying temperatures.

Mathematics Involved

Common fractions, decimal fractions

Application

The specific gravity of a fully charged battery will be 1.275 at 80°F. A hydrometer check of a battery is made at 40°F. What reading would indicate a fully charged battery? (Specific gravity decreases 0.001 for each drop of 2 1/2 degrees F.)

Solution:

With a temperature decrease of 40°F., the reading should be 1.275 — (40 ÷ 2 1/2) (.001) = .016 less than 1.275; therefore, a fully charged battery at 40°F. should show a specific gravity of 1.259.

Calculate number of times ignition points open during a specified length of time.

Mathematics Involved

Ratios

Application

(a) How many times will the ignition points open per minute on a one-cylinder four-stroke cycle engine running at 180 r.p.m.? (Ignition points open once per cylinder for each two revolutions.) (b) A Mercury V-8 engine idles at 450 r.p.m. How many times will the ignition points open when it idles for four minutes? (Ignition points open once per cylinder for each two revolutions.)

Solution:

(a) 180 ÷ 2 = 90 times. (b) (450 ÷ 2) × 8 × 4 = 7200 times.

Typical Student Errors in Using Paper/Pencil Computation*

Addition

- Forgetting to carry
- Carrying the wrong number
- Not lining up correctly the numbers to be added

Subtraction

- Subtracting a number from zero and instead of borrowing, get the same number
- Forgetting to decrease the number from which they are borrowing
- Neglecting to borrow when necessary
- Lining up the numbers incorrectly

Multiplication

- Neglecting to carry
- Adding before multiplying
- Multiplying the number that was carried instead of adding it
- Forgetting to indent the second set of numbers to maintain proper place value

Division

- Keeping numbers in their proper places
- Knowing how to add, subtract, and multiply

Fractions

- Inverting or turning a fraction upside down

Decimals

- Failing to line up numbers so that decimal points are under each other

*We feel the emphasis should be on teaching problem solving skills in which computation is only one of the skills. Using calculators, charts, tables, computers as tools are encouraged.